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THE TEA RESEARCH INSTITUTE,
St. Coombs, Talawakelle,
Ceylon.

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FACTORS AFFECTING SHOOT PRODUCTION IN TEA *(CAMELLIA SINENSIS)* WHEN GROWN AS A PLANTATION CROP

1. SOME EFFECTS OF THE LENGTH OF PLUCKING ROUND ON FLUSH SHOOT PRODUCTION

G. B. Portsmouth

General Introduction.—The tea of commerce is a product made from the still tender apical portions of secondary and higher order shoots. Accordingly, many of the problems arising in connection with the cultivation of *Camellia sinensis* as a plantation crop necessitate an understanding of the factors affecting shoot production.

Previous work by Tubbs (1936, 1937) and Bond (1942, 1945) dealing with shoot production in commercially cultivated tea has all been based on observations made on very heterogeneous field material of seedling origin. In more recent years the development of vegetative propagation has permited the use of uniform clonal material for such observations, thus greatly increasing their precision and reliability. It is accordingly the aim of the present series of papers to report the results of some of the observations on shoot production in the tea bush, as affected by normal cultivation and plucking practices, which have been made using the pure line clonal material now available on St. Coombs.

At this elevation (4,500 feet) the bushes are normally pruned every 3 or 4 years by cutting across the branches at a level of from 18 to 24 inches from the ground. As soon as the primary shoots have developed sufficiently they are broken back to a level, approximately two mature leaves above the pruning level, to form a plucking table. All secondary shoots formed above this second level constitute the "crop" shoots, which are normally plucked every 9 or 10 days according to a definite system.

Tea is a plant whose shoots exhibit the phenomenon of periodic growth (Bond 1942). This means that, while the majority of crop shoots are still in their first flush of active growth at the time of plucking, there are some shoots present in which growth has already temporarily ceased. The former will be designated "flush" shoots and the latter "banji" shoots, in accordance with local usage. For cropping purposes, flush shoots are normally considered ready for plucking as soon as there are three full leaves clear of the bud. Plucking is carried out by removing the top two or more open leaves and terminal bud, but always leaving one mature leaf below the point of plucking. Banji shoots are, however, always plucked as soon as active growth has ceased, provided one mature leaf can be left below the point of plucking.

Due to the length of plucking round, the crop harvested consists of a mixture of shoots comprising bud plus 2 leaves, bud plus 3 leaves, bud plus 4 leaves etc., the relative proportions depending on the rate of growth prevailing during the plucking interval.

As a consequence of one mature leaf being left on the bush when each crop shoot is plucked, the height of the plucking table gradually rises as the pruning cycle progresses until, by the time the next prune is due, it may be as much as 3 or even 4 feet from the ground.

Crop, as harvested, consists of a mixture of both flush and banji shoots. In the case of flush shoots the effects of external factors are not complicated by the variations

in shoot size which are introduced by the changes in terminal bud activity which accompany the onset of the banji state. Accordingly, in this and the following paper, attention will be concentrated on the changes occurring in actively growing flush shoots, as being more readily susceptible to accurate analysis.

Experimental.—For the present series of observations use was made of a small area of T.R.I. Clone No. 4, planted in 1940, at a spacing of $3\frac{1}{2}' \times 3'$. This area had been last pruned at 18" from ground level on 5-2-48 so that the bushes were just over 13 months from pruning when recording was started on 14-3-49.

The experiment comprised a total of some 80 bushes, divided into 4 blocks, each containing 10 pairs of bushes. One bush of each pair was plucked at 7 day intervals throughout and the other at 14 day intervals. There was thus a total of 40 bushes plucked weekly and 40 bushes plucked fortnightly.

At each plucking the flush shoots from each treatment were collected separately by blocks and brought at once into the laboratory. Here they were sorted out into groups consisting of shoots made up of bud plus 2 leaves, bud plus 3 leaves, bud plus 4 leaves, etc., counted, weighed and recorded. Material consisting of a bud and more than two leaves was then reduced to bud plus 2 leaves and again weighed and recorded. All banji shoots were also plucked but were not recorded. Recording was concluded on 13-11-50.

The experimental area was manured in accordance with normal estate practice in July 1948, May 1949 and June 1950.

Results.—(a) Composition of crop harvested.—The main effects of the different lengths of plucking round were found in the changes produced in the proportions of the various shoots comprising the crop harvested, in their respective individual weights and in the total number of each type of shoot harvested.

Figures showing the average composition of the crop harvested for the first full year of plucking, reduced to a single bush basis, are given in Table 1.

Table 1. *Composition of crop harvested per bush from* 14-3-49 *to* 6-3-50.

PLUCKING PERIOD	WEEKLY				FORTNIGHTLY				
Type of Flush Shoot	*B+2	B+3	B+4	Total	B+2	B+3	B+4	B+5	Total
Total number of plucks	—	—	—	52	—	—	—	—	26
Total number of shoots	434.1	136.4	1.5	572.0	196.0	150.7	20.0	0.1	366.8
Percentage composition by number ...	75.9	23.8	0.3	100.0	53.4	41.1	5.5	—	100.0
Total fresh weight of shoots (gm) ...	185.0	95.2	1.9	282.1	86.0	128.1	28.9	0.2	243.2
Percentage composition by weight ...	65.6	33.8	0.6	100.0	35.4	52.7	11.9	—	100.0
Mean fresh weight of each shoot (gm) ...	0.43	0.70	1.23	0.49	0.44	0.85	1.44	2.18	0.66
Mean number per pluck	8.35	2.62	0.03	11.00	7.54	5.79	0.77	—	14.10
Mean number per week	—	—	—	11.00	—	—	—	—	7.05

* *Note*—In the column headings of this table B + 2 stands for a bud plus 2 leaf shoot, etc. etc.

It will be seen that the main effects of increasing the length of the plucking round from a week to a fortnight were:—

(1) A decrease in the total number of shoots harvested per bush from 572.0 to 366.8 or by 35.9 per cent. This represented a reduction in the weekly rate of new flush production from 11.00 to 7.05 shoots per bush.

(2) An increase in the proportion of shoots with more than 2 leaves. This was equivalent to a reduction in the percentage of the desired bud plus 2 leaf shoots from 75.9 per cent to 53.4 per cent.

(3) An increase in the weight of each individual shoot harvested from a mean value of 0.49 gm. to a mean value of 0.66 gm. or by 25.8 per cent. This increase was negligible in the case of the desired bud plus 2 leaf shoot, but increased markedly with each increase in the leaf number of the shoot harvested.

Contrary to expectation, the increase in individual shoot weight, resulting from the longer round, was entirely insufficient to make up for the reduction in the total number of shoots harvested. As a consequence there was a net decrease in the weight of the total crop harvested from 282.1 gm. to 243.2 gm. or some 13.8 per cent.

(b) Quality of crop harvested.—The quality of the tea that can be made from the crop harvested at any given plucking depends to a large extent upon its composition, it terms of bud plus 2 leaves, bud plus 3 leaves, etc. In this connection it is generally accepted that the best quality tea will be made if only the tenderest shoots, consisting of bud plus 2 leaves, are accepted for manufacture. If this standard of "fine plucking" is adopted for a comparison of the effects of weekly and fortnightly plucking rounds, then it is necessary for all shoots harvested to be reduced by "breaking back" to bud plus 2 leaf shoots and the basal harder portions discarded before final yields of crop suitable for quality manufacture are recorded.

An analysis of the crop produced per bush, reduced to shoots of bud plus 2 leaves only, over the period 14-3-49 to 6-3-50 is given in Table 2.

Table 2. *Analysis of crop produced per bush as Bud + 2 leaf shoots only.*

PLUCKING PERIOD	WEEKLY		FORTNIGHTLY	
Type of Flush Shoots Plucked	Weight (gm.)	Percentage	Weight (gm.)	Percentage
Bud plus 2 leaves	185.0	65.6	86.0	35.4
Bud plus 3 leaves	95.2		128.1	
Bud plus 4 leaves	1.9	34.4	28.9	64.6
Bud plus 5 leaves	—		0.2	
Total weight plucked	282.1	100.0	243.2	100.0
Weight discarded	48.1	17.1	84.8	34.9
Total crop as Bud plus 2 leaf shoots	234.0	82.9	158.4	65.1

This analysis shows that only 35.4 per cent of the fortnightly plucked shoots consisted of bud plus 2 leaf shoots, immediately acceptable for manufacture, as compared with 65.6 per cent in the case of the weekly plucked shoots. The large increase in the proportion of older shoots in the flush plucked fortnightly meant that much more "breaking back" had to be carried out on this material. As a consequence some 34.9 per cent by weight of the material plucked fortnightly had to be discarded as compared with only 17.1 per cent of the weekly plucked material. Thus, if a "fine plucking" standard was accepted, rather more than twice the amount of material had to be discarded from the fortnightly pluckings than from the weekly pluckings.

It can, therefore, be postulated that if the whole of the crop, as plucked, was accepted for manufacture, that from fortnightly plucked bushes would produce a much poorer quality tea than that from weekly plucked bushes.

In addition to the loss of quality brought about by an increase in the length of plucking round reference may again be made to the actual loss of crop which has been recorded from this cause. When the whole of the crop, as plucked, was accepted for manufacture, this amounted to 38.9 gms. per bush, or 13.8 per cent of the total of 282.1 gms. produced by weekly plucking. If, however, a "fine plucking" standard was introduced the loss rose to 75.6 gms. per bush, which was 32.3 per cent of the 234.0 gms. of crop accepted for manufacture from the weekly plucking. This increase in the percentage loss of crop affords yet another measure of the loss of quality produced by an increase in the length of plucking round.

Discussion and Conclusions.—From the commercial standpoint it is obviously desirable for the planter to aim at producing the largest crop possible while still maintaining a high standard of quality. It is clear that above a certain optimal time interval the quality of the crop harvested must decrease with any increase in the length of the plucking round.

The experiment afforded no evidence as to the length of this optimal time interval, but from another experiment, reported later in this series (Portsmouth and Rajiah 1957), it is known that, at this elevation, the average time interval between the unfolding of each new flush shoot leaf is approximately 9 days. This time interval corresponds exactly with the 9 day plucking round which has been adopted by most planters on estates at this elevation. It would appear that this is no chance coincidence, since it seems reasonable to suppose that a plucking round based on the time interval between the unfolding of successive shoot leaves would permit of the greatest possible weight of the desired bud plus 2 leaf shoots being harvested. Plucking intervals in excess of 9 days will, as has been demonstrated, undoubtedly produce crops containing an increased proportion of the coarser shoots with more than 2 leaves and so give poorer quality teas.

Under the conditions of this experiment, *i.e.* with a rigidly controlled method of plucking, it has been shown that weekly plucking produced a considerably greater yield of crop in the form of flush shoots. However it is premature to draw any practical conclusion from this finding for the following reasons:—

(1) No information is presented regarding the changes in the proportion of banji shoots produced by changes in the length of the plucking round. In normal estate plucking banji shoots may constitute an appreciable proportion of the crop harvested.

(2) Estate plucking practice is not generally so closely controlled as was the present experiment. As a consequence psychological factors may lead to pluckers harvesting an undue proportion of the crop from those bushes displaying the largest

numbers of shoots ready for plucking, or to them avoiding entirely those bushes with a large proportion of banji shoots.

Information is, however, being collected in connection with banji shoot production and will it is hoped be presented in a later paper of this series.

Summary.—An experiment is described in which uniform bushes of T.R.I. Clone No. 4 were plucked to a predetermined standard, at weekly and fortnightly intervals, for some 21 months and the different types of flush shoots regularly harvested, recorded and weighed.

Increasing the length of the plucking interval from a week to a fortnight resulted in:—

(1) A decrease in the total number of flush shoots harvested per bush.

(2) An increase in the proportion of shoots with more than 2 leaves.

(3) An increase in the mean weight of each individual shoot harvested.

(4) A decrease in the manufacturing quality of the crop harvested.

The increase in the mean weight of the individual shoots harvested was not, however, sufficient to counter-balance the reduction in the total number of shoots harvested and there was thus a net loss of crop with the longer plucking interval.

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FACTORS AFFECTING SHOOT PRODUCTION IN TEA *(CAMELLIA SINENSIS)* WHEN GROWN AS A PLANTATION CROP

II. THE INFLUENCE OF CLIMATIC CONDITIONS AND AGE FROM PRUNING ON FLUSH SHOOT PRODUCTION

G. B. Portsmouth

Introduction.—The first paper of this series (Portsmouth 1957a) described the results of a plucking experiment carried out on an area of clonal tea (T.R.I. Clone No. 4) in so far as they were affected by the applied treatments, namely, weekly and fortnightly plucking intervals. For this purpose it was sufficient to utilise only the records obtained during the first year of plucking, although the experiment continued in operation from 14-3-49 to 13-11-50, or for some 21 months. In the present paper it is proposed to make use of the full period of the experiment to determine, if possible, in what way climatic conditions and age from pruning may influence flush shoot production.

With regard to age from pruning it may be noted that the experiment was in operation during a period of 14 to 35 months from pruning. With a cycle length of 36 months the experiment thus covered almost the whole of the period during which flush shoot production might be expected to have settled down and to be determined mainly by plucking procedure, climatic factors and age from pruning. This is not the case in the early months of the cycle since, as Tubbs (1937) points out, there is initially, during recovery from pruning, a very rapid increase in shoot production which subsequently levels off as the plucking table becomes fully formed and factors such as light intensity and internal competition for available nutrients start to limit the rate of new shoot production.

Weather Conditions.—St. Coombs estate is situated, at an elevation of 4,500 feet, approximately midway between the towns of Hatton and Nuwara Eliya in the Central Province of Ceylon. The district is one which receives both the south west and the north east monsoons, and weather conditions throughout the year are mainly governed by the prevailing monsoon. There is comparatively little temperature variation. Thus in 1949 the mean maximum temperature ranged from 80.9°F in March to 70.0°F in June, while the mean minimum temperature ranged from 52.0°F in February to 60.1°F in June. Similarly in 1950 the mean maximum temperature ranged from 77.6°F in March and April to 68.3°F in July, while the mean minimum ranged from 52.7°F in January to 60.0°F in June.

Rainfall and mean daily sunshine hours vary over a very much wider range, being essentially monsoonal in character. Conditions from January to April are usually fine and bright with little rainfall or cloud. This is followed by the onset of the south west monsoon, around the middle of May, when conditions become misty and overcast with almost continuous light rain. Towards October the south west monsoon gives way to the north east, which is characterised by bright mornings with heavy showers during the afternoons.

It may thus be reasonably expected that, if there is any influence of climatic factors on flush shoot production, it will be found to operate through changes in

either rainfall or sunshine hours. Monthly data for rainfall, sunshine hours and wet days (days on which more than 0.04 inches of rain fell), at St. Coombs, are accordingly given in Table 3.

*Table 3. *Meteorological Data—St. Coombs.*

MONTH	RAINFALL Inches	MEAN DAILY SUNSHINE Hours	WET DAYS
1948			
November	6.38	5.53	16
December	6.92	3.58	13
1948 whole year	87.66	5.31	182
1949			
January	3.23	6.88	7
February	0.45	8.42	4
March	1.66	8.42	1
April	8.04	6.02	17
May	7.06	5.28	19
June	11.38	2.63	19
July	11.16	3.17	26
August	9.55	4.07	23
September	8.28	3.17	21
October	10.80	4.87	20
November	8.24	5.17	15
December	7.03	2.62	11
1949 whole year	86.88	4.82	191
1950			
January	0.82	7.10	7
February	2.07	7.03	8
March	1.83	7.58	8
April	2.85	6.70	7
May	9.29	5.32	12
June	9.21	2.72	21
July	13.40	2.17	30
August	7.18	2.77	25
September	12.36	3.53	17
October	5.28	3.97	19
November	6.35	4.98	12
December	2.22	5.03	10
1950 whole year	72.86	4.89	176

**Note.* As the same data are involved tables are numbered consecutively with paper I of this series.

Sunshine hours appear to vary inversely with rainfall and over the period November, 1948, to November, 1950, which is made use of in subsequent calculations,

show a correlation coefficient $r_{RS} = -0.8241$, which for n=25 is very highly significant.

The number of wet days is also very closely linked with the monthly rainfall and, over the same period, shows an even stronger correlation $r_{RW} = +0.8330$.

It would, therefore, appear to be reasonably justifiable to consider rainfall as the dominant climatic factor operating at St. Coombs.

Flush Shoot Number.—The average numbers of each type of flush shoot harvested per pluck each month, reduced to a single bush basis, are given in Table 4.

Table 4. *Average number of flush shoots harvested per bush at each pluck*

	PLUCKED WEEKLY				PLUCKED FORTNIGHTLY				
	*B + 2	B + 3	B + 4	Total	B + 2	B + 3	B + 4	B + 5	Total
1949—									
March ...	1.87	—	—	1.87	2.98	0.40	—	—	3.38
April ...	5.70	1.17	—	6.87	5.88	1.79	0.01	—	7.68
May ...	9.48	4.16	0.03	13.77	6.80	8.38	1.84	0.02	17.04
June ...	2.31	0.03	—	2.34	2.24	0.21	0.01	—	2.46
July ...	15.89	2.68	—	18.57	11.51	12.09	1.63	0.01	25.24
August ...	4.29	1.21	—	5.50	3.40	2.24	0.26	—	5.90
September	9.63	5.53	0.18	15.34	6.16	5.68	0.92	—	12.76
October ...	8.09	2.24	0.04	10.37	9.72	7.11	0.82	—	17.65
November	15.30	4.79	0.02	20.11	12.85	8.49	1.06	—	22.40
December	8.07	3.88	0.01	11.96	7.17	7.44	1.29	—	15.90
1950									
January ...	10.28	3.47	0.06	13.81	4.26	3.49	0.31	—	8.06
February	9.05	1.79	—	10.84	14.16	9.16	0.46	—	23.78
March ...	4.28	1.01	—	5.29	5.85	1.78	0.06	—	7.69
April ...	4.41	0.35	—	4.76	4.46	0.93	—	—	5.39
May ...	3.36	0.52	—	3.88	5.92	1.07	0.02	—	7.01
June ...	11.39	1.66	0.01	13.06	14.34	3.47	0.05	—	17.86
July ...	9.55	0.99	0.01	10.55	7.05	1.31	—	—	8.36
August ...	4.59	0.21	—	4.80	4.13	0.40	—	—	4.53
September	9.16	0.97	—	10.13	12.59	1.35	—	—	13.94
October ...	4.98	0.71	0.01	5.70	6.24	2.03	0.15	—	8.42
November	7.39	2.16	—	9.55	12.00	2.70	0.15	—	14.85

* *Note.* In the column headings of this and subsequent tables B + 2 stands for a bud plus 2 leaf shoot, etc. etc.

Considering the totals only; there is no obvious correlation with the meteorological data of Table 3. On the contrary, there would appear to be indications of a regular rhythmic pattern in the form of alternating maxima and minima. Monthly variations of this nature are particularly marked in the case of the weekly plucked bushes from May, 1949, to January, 1950, and again from August to November, 1950. As may be expected from the reduced number of plucks in each monthly mean, the pattern, although still recognisable, is somewhat less pronounced in the case of the fortnightly plucked bushes.

This observed variation in the number of flush shoots harvested month by month presumably owes its origin to a similar innate periodicity to that which manifests itself in the individual shoot in the form of alternate periods of active growth and dormancy (Bond 1942).

The only indication of any influence of climatic conditions on the number of flush shoots produced would appear to be a suppression of the expected periodic maxima, which is observable in the case of the weekly plucked bushes, as a consequence of the very dry weather experienced from January to April, 1950. With only 0.82 inches of rain in January, 1950, and less than 4 inches in each of the three following months this period can be considered as one of true drought. Provided, therefore, that growth is not limited by actual water shortage it appears probable that this rhythmic variation in flush shoot number is completely independent of external climatic factors.

The effect of age from pruning on flush shoot number is probably best brought out by comparing means for the two periods March to November, 1949, and March to November, 1950. The relevant data are accordingly presented overleaf in Table 5.

From this table it is evident that the effect of an increase in the mean age of the bushes from pruning, of one year, has been to bring about a general decrease in the numbers of flush shoots harvested at each pluck. This decrease was 31.3 per cent of the total in the case of the weekly plucked bushes, and 32.1 per cent in the case of the fortnightly plucked bushes. These figures are in remarkably close agreement and undoubtedly represent a real slowing down in the overall growth rates of the bushes.

If the growth rates of the individual flush shoots had remained constant it could have been expected that the percentage composition of the crop harvested would have remained more or less unaltered. As it is the proportion of bud plus 2 leaf shoots, which require the least time to reach a state of readiness for plucking, has increased very considerably with time, which again indicates a slowing down of the general growth rate. This increase in the proportion of bud plus 2 leaf shoots was from 76.3 per cent to 88.0 per cent, in the case of the weekly plucked bushes, and from 52.5 per cent to 82.3 per cent, in the case of the fortnightly plucked bushes. This latter increase is particularly striking since, with the longer plucking interval, there should have been ample time for more bud plus 3 leaf shoots to have developed had not there been a decrease in the individual shoot growth rate.

Table 5. *Effect of age from pruning on mean numbers of flush shoots harvested per bush at each pluck.*

PERIOD	Months from pruning	PLUCKED WEEKLY				PLUCKED FORTNIGHTLY				
		B + 2	B + 3	B + 4	Total	B + 2	B + 3	B + 4	B + 5	Total
Mar.—Nov. 1949 ...	14—23	8.16 (76.3%)*	2.51 (23.4%)	0.03 (0.3%)	10.70	7.19 (52.5%)	5.67 (41.4%)	0.83 (6.0%)	0.01 (0.1%)	13.70
Mar.—Nov. 1950 ...	26—35	6.47 (88.0%)	0.87 (11.9%)	0.01 (0.1%)	7.35	7.65 (82.3%)	1.60 (17.2%)	0.05 (0.5%)	—	9.30
Decrease after 1 year ...	—	1.69	1.64	0.02	3.35	— 0.46	4.07	0.78	0.01	4.40

* *Note.*—Figures in brackets represent the percentage composition of the crop harvested.

Flush Shoot Weight.—The average fresh weights of the various types of flush shoot harvested each month are given in Table 6.

Table 6. *Average fresh weights of individual flush shoots (gm).*

	PLUCKED WEEKLY			PLUCKED FORTNIGHTLY			
	B+2	B+3	B+4	B+2	B+3	B+4	B+5
1949—							
March	0.25	0.40	—	0.29	0.48	—	—
April	0.34	0.57	1.10	0.31	0.48	0.90	—
May	0.37	0.61	1.20	0.41	0.73	1.25	2.10
June	0.41	0.93	—	0.41	0.63	1.90	—
July	0.46	0.70	—	0.50	0.95	1.49	2.40
August	0.44	0.72	—	0.48	0.88	1.42	—
September	0.49	0.79	1.28	0.51	1.03	1.76	—
October	0.45	0.77	1.41	0.47	0.89	1.48	—
November	0.48	0.73	1.10	0.51	0.96	1.59	—
December	0.48	0.78	1.05	0.53	1.02	1.63	—
1950—							
January	0.41	0.65	1.09	0.46	0.89	1.27	—
February	0.31	0.51	—	0.32	0.56	1.02	—
March	0.34	0.48	—	0.36	0.66	1.12	—
April	0.23	0.36	—	0.28	0.44	—	—
May	0.20	0.29	—	0.22	0.30	0.55	—
June	0.25	0.35	0.35	0.27	0.39	0.63	—
July	0.30	0.50	0.55	0.32	0.58	—	—
August	0.39	0.64	—	0.46	0.68	—	—
September	0.43	0.70	—	0.42	0.74	—	—
October	0.49	0.89	1.65	0.50	0.87	1.41	—
November	0.46	0.68	—	0.58	0.89	1.48	—

As soon as the curves for the monthly variations in weight of the bud plus 2 leaf shoots were plotted it was evident that they were markedly similar in shape to the curves obtained by plotting the meteorological data of Table 3. This suggested the existence of a definite relationship between climatic conditions and shoot weight. Accordingly, a series of correlation co-efficients were calculated in which shoot weight was related to rainfall over a period extending backwards in time from the month of plucking up to 4 months before plucking. The respective correlation co-efficients obtained in this way are given in Table 7.

Table 7. *Correlation co-efficients. Monthly rainfall and average fresh weights of B + 2 flush shoots.*

MONTH IN WHICH RAIN FELL	PLUCKED WEEKLY	PLUCKED FORTNIGHTLY
Same month as plucking	+ 0.2320	+ 0.1291
1 month before plucking	+ 0.6336**	+ 0.6245**
2 months before plucking	+ **0.7036****	+ **0.7238****
3 months before plucking	+ 0.6911**	+ 0.6587**
4 months before plucking	+ 0.4499*	+ 0.4722*

Significance levels where n = 21

	P	r
**	.01	0.5487
*	.05	0.4329

The correlations with the rainfall, from 1 to 3 months before plucking, are all highly significant at the 1 per cent level. From the relative value of the co-efficients it is evident that a maximum correlation is reached with rainfall about 2 months before plucking and that all the co-efficients fall on a regular second order curve. By combining the data from both sets of pluckings the following curve of closest fit was calculated:—

$$r = 0.2037 - 0.4743\ t - 0.1034\ t^2$$

where t represents the time in months. Differentiating this expression and equating to zero gives a maximum calculated value of r = + 0.7476 at 2.29 months before plucking.

The extent of this correlation with rainfall and the goodness of fit of the calculated curve is shown in Figure 1.

Correlation co-efficients, calculated in the same way as above, for rainfall and the fresh weights of bud plus 3 leaf shoots are given in Table 8.

Table 8. *Correlation co-efficients. Monthly rainfall and average fresh weights of B + 3 flush shoots.*

MONTH IN WHICH RAIN FELL	PLUCKED WEEKLY	PLUCKED FORTNIGHTLY
Same month as plucking	+ 0.2988	+ 0.1052
1 month before plucking	+ 0.5893**	+ 0.5940**
2 months before plucking	+ **0.6525****	+ 0.6877**
3 months before plucking	+ 0.5516**	+ **0.7065****
4 months before plucking	+ 0.2806	+ 0.4824*

Significance levels where n = 21

	P	r
**	.01	0.5487
*	.05	0.4329

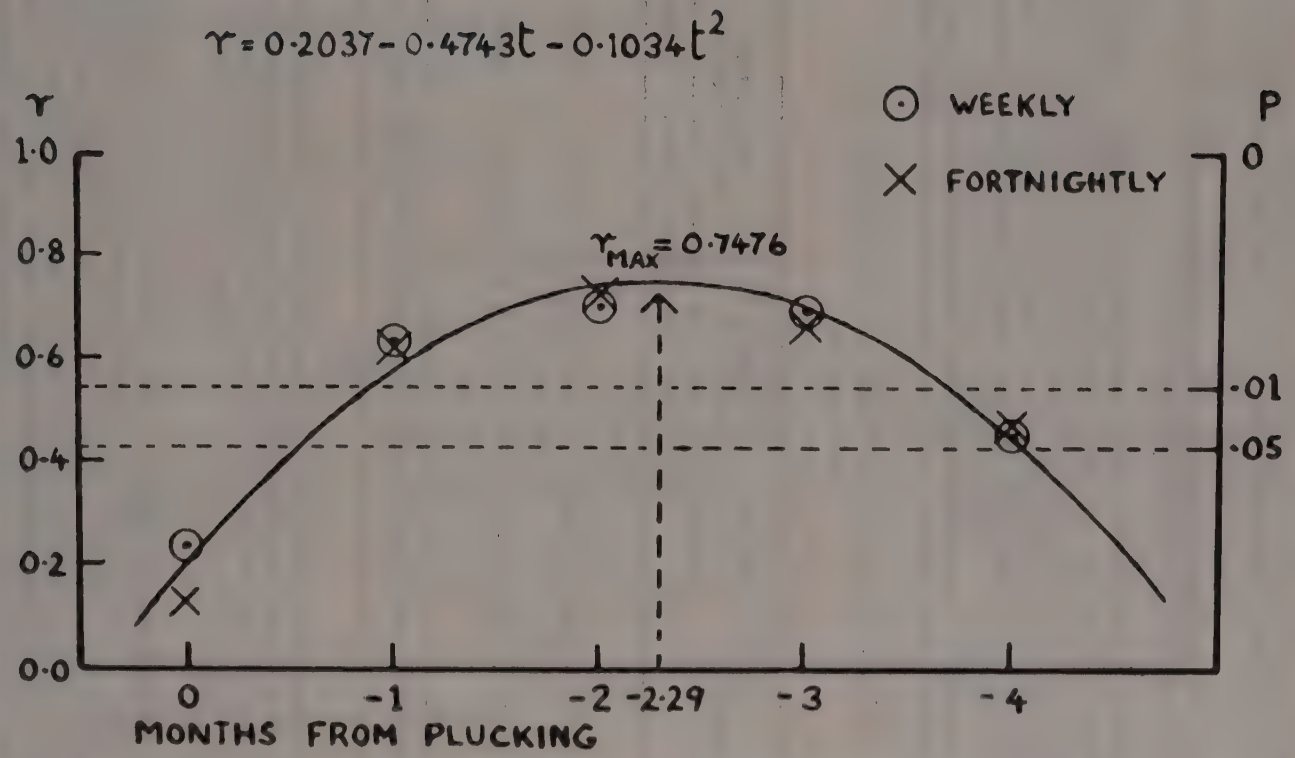

Figure 1. Diagram to show extent of correlation between rainfall and fresh weights of bud plus 2 leaf shoots. The calculated curve of closest fit is drawn in.

The pattern is very similar to that of Table 7 and again all correlations with rainfall from 1 to 8 months before plucking are highly significant at the 1 per cent level. Combining the data as before gives the following curve of closest fit:—

$$r = 0.2165 - 0.4379\,t - 0.09956\,t^2$$

which, on differentiating and equating to zero, gives a maximum calculated value of $r = +0.6880$, at 2.20 months before plucking.

As might be expected, from the greater variability of the bud plus 3 leaf material, the goodness of fit of this second curve is somewhat less close (see Figure 2) than in the case of the bud plus 2 leaf material. However, both calculated maximum correlation co-efficients are obviously very highly significant and, indicate that the average weight of a plucked flush shoot is very largely influenced by the weather conditions prevailing some two and a quarter months before the date of plucking.

Similar data, to that already presented in Table 5 to show the effect of age from pruning on flush shoot number, is given for individual flush shoot weight in Table 9.

Table 9. *Effect of age from pruning on mean fresh weights of individual flush shoots (gm).*

PERIOD	Months from Pruning	PLUCKED WEEKLY			PLUCKED FORTNIGHTLY			
		B + 2	B − 3	B + 4	B + 2	B + 3	B + 4	B + 5
March—Nov. 1949	14—23	0.44	0.71	1.27	0.46	0.88	1.45	2.18
March—Nov. 1950	26—35	0.34	0.54	0.85	0.37	0.61	1.24	—
Decrease after 1 year	—	0.10	0.17	0.42	0.09	0.27	0.21	—

Little need be said about this table except that it shows that an increase of one year in the mean age of the bushes from pruning has brought about a similar decrease in all individual shoot weights. The effect is very like that previously demonstrated for flush shoot number and again points to a decrease in the individual shoot growth rate with time.

Discussion and Conclusions.—Before discussing the results reported in the present paper it is as well to obtain a clear idea as to how far any conclusions drawn may be generally applicable. As mentioned in the previous paper Portsmouth 1967a), one of the commonest difficulties that arises in reconciling the results of scientific experiments with estate practice is due to the very large extent to which the human element may influence estate results. At present the tea crop in Ceylon is harvested entirely by hand. Accordingly, although definite plucking programmes and standards of plucking are laid down, these are seldom rigidly adhered to. The

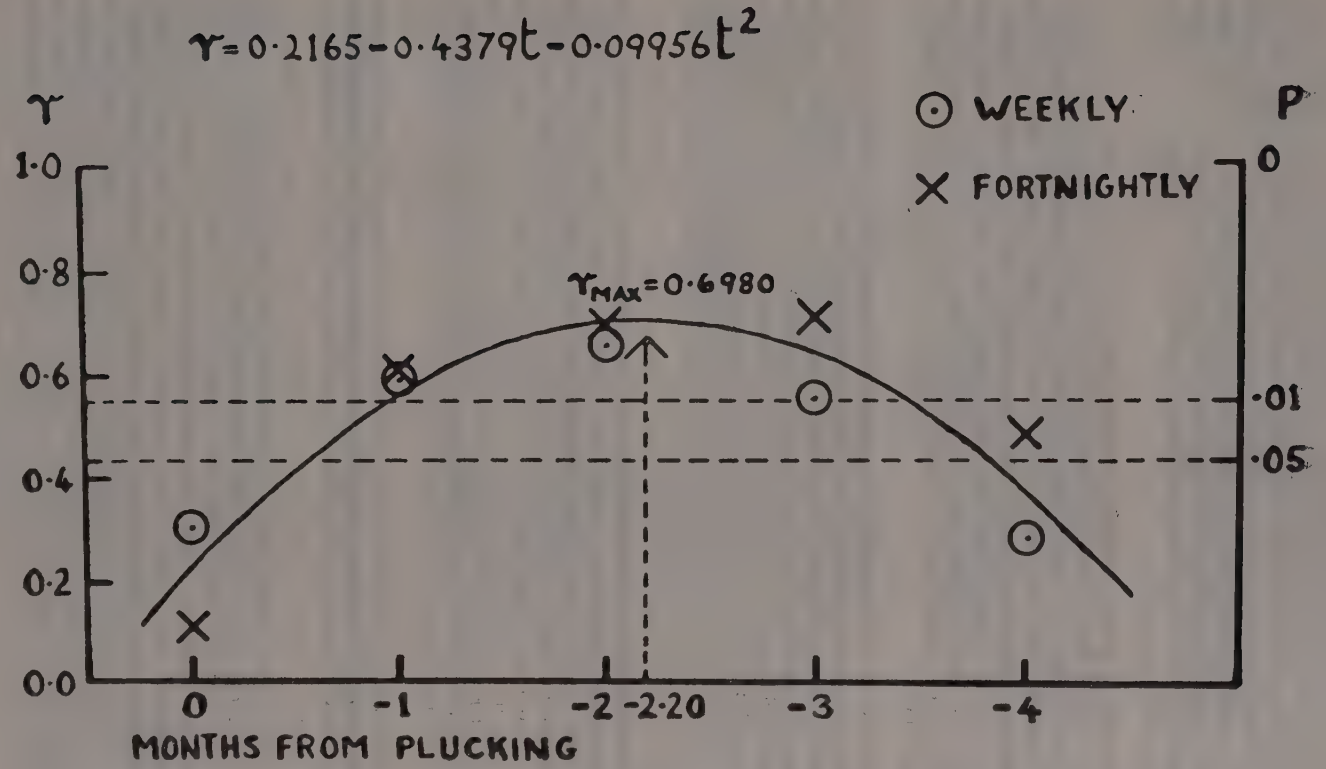

Figure 2. Diagram to show extent of correlation between rainfall and fresh weights of bud plus 3 leaf shoots.. The calculated curve of closest fit is drawn in.

number of pluckers carried by an estate is more or less fixed so that, when seasonal "rushes" of crop are experienced, plucking intervals increase and many crop shoots that should be harvested remain ungathered. On the other hand, when crop is short, although the plucking intervals are correct, many immature shoots are prematurely gathered as a direct consequence of the pluckers' need to bring in their daily poundage. Under such conditions, therefore, it is not surprising that the result of rigidly controlled scientific experiments are not always strictly reproducible when put into practice on an estate scale. However, this is a relatively minor difficulty, since the validity of the experimental result is uncontested, and it merely remains for the working planter to bring his estate practice more closely into line with scientific knowledge.

The degree to which climatic conditions vary from estate to estate in Ceylon presents a much more serious difficulty when it comes to considering how far any conclusions based on climatic data can be justifiably extended. Variations in annual rainfall, from under 100 inches to more than 200 inches in only a few miles, are common, while many tea growing areas receive only one monsoon instead of the two experienced at St. Coombs. Accordingly, until such time as similar results have been obtained in other areas, it seems advisable to restrict the validity of any climatic effects reported to the immediate neighbourhood in which the experiment was carried out.

There is also considerable uncertainty at present as to how far the results obtained, using one particular clone for experimentation, will be reproducible when different clones are employed. However, such evidence as is available indicates that responses tend to differ in degree rather than in kind. Accordingly, in the absence of evidence to the contrary, it seems reasonable to suppose that most clones will respond in the same way to similar conditions, although the response levels will vary from clone to clone. Experiments are actually in progress with a wide selection of different clones and this question will, therefore, be discussed in more detail when results are reported in later papers.

With the above considerations in mind, it appears safe to conclude that in, the St. Coombs neighbourhood, climatic conditions, of which rainfall is the dominant factor, have a marked influence on the individual weights of all flush shoots harvested. The correlations with rainfall, one, two and three months prior to plucking, are all positive and highly significant. The calculated correlation co-efficients for bud plus 2 leaf and bud plus 3 leaf shoots reach maxima at an average time about two and a quarter months before plucking. The rainfall some two and a quarter months prior to plucking thus appears to largely predetermine the individual weights of the flush shoots harvested.

This finding is of considerable interest since it indicates the possibility, when other factors have been more fully investigated, of being able, on the basis of recorded climatic data and growth observations, to predict crop levels two months or more in advance.

Consideration of the manner in which climatic influences operate to control final flush shoot weight is naturally somewhat speculative. However, it is known from other work on T.R.I. Clone No. 4 (Portsmouth and Rajiah) that the interval between the unfolding of each successive foliage leaf on the developing shoot is approximately 9 days. Now a shoot, which is harvested as a bud plus 2 leaf shoot, may be expected to consist of two scales, 1 fish leaf and 3 foliage leaves, making a total of some six expanded appendages in all. The three foliage leaves will have taken a total of 27 days to unfold and even, if, following Bond (1945), a somewhat longer interval, say 12 days, is allowed for the unfolding of each of the other three appendages, the whole shoot may be expected to have taken not more than about

63 days to develop from bud-break. This period is rather less than that represented by the two and a quarter months before plucking when climatic influences reach their maximum. As growth in size and weight of the developing shoot is presumably exponential in character in, at least, the early stages it seems reasonable to suppose that it is through their effect on the initial sizes reached by the shoot primordia, prior to the bud breaking into active growth, that these climatic influences may operate. On this suggestion it is supposed that greater rainfall will almost immediately lead to an increase in the supplies of water and soluble nutrients at the growing points, and so enable the primordia to increase in size before bud-break and active growth commences.

Except during periods of drought climatic conditions appear to have little or no effect on the number of flush shoots produced per bush. On the contrary, flush shoot number exhibits a rhythmic variation with a series of maxima and minima which, in the case of T.R.I. Clone No. 4, are spaced about two months apart. During conditions of actual drought the expected maxima are suppressed. This observed periodicity, which obviously owes its origin to the number of buds which "break" at any given time, is considered to be innate and similar in character to that which manifests itself in the individual shoot in the form of alternate periods of active growth and dormancy (Bond 1942).

The effect of increasing age from pruning is evident as a decrease in both flush shoot number and individual shoot weight, which indicates a decrease in the general growth rate with time. There is, of course, a slight possibility that climatic factors are also concerned in bringing about this effect since rainfall in 1950 was some 16 per cent less than in 1949. However, as the decreases in shoot numbers alone reached twice this figure, without taking into account the equally large weight decreases it seems reasonable to suppose that age from pruning had played a major part in bringing about the observed effect.

In this connection it may be noted that the type of growth induced by plucking is essentially sympodial in nature. As a consequence, as the age from pruning increases, the new crop shoots tend to develop from branches of higher and higher order. It is, accordingly, suggested that it is this increase in the complexity of the bushes' branch system, during the course of the pruning cycle, which operates to bring about this decrease in the general growth rate with time.

Acknowledgement.—The assistance and enthusiastic co-operation of Messrs. F. H. Kehl and E. S. Rajiah in supervising the field work and collecting all the varied data required in connection with this experiment is gratefully acknowledged.

Summary.—This paper presents the results of a further analysis of the data obtained from the experiment previously described (Portsmouth 1957a).

Climatic conditions, of which rainfall is the dominant factor, existing some two and a quarter months prior to plucking, appear to largely predetermine the individual weights of the flush shoots harvested.

It is suggested that this effect is brought about by increased rainfall increasing the supplies of water and soluble nutrients available at the growing points, thus enabling the shoot primordia to increase in size before active growth begins.

Except during drought, the numbers of flush shoots harvested were independent of climatic conditions, being apparently determined by an innate periodicity.

An increase in the age of the bush from pruning resulted in (1) a decrease in flush shoot number, (2) a decrease in the individual flush shoot weight.

These two results are considered to be due to a decrease in the general growth rate, brought about by the increasing complexity of the bushes, branch system.

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FACTORS AFFECTING SHOOT PRODUCTION IN TEA *(CAMELLIA SINENSIS)* WHEN GROWN AS A PLANTATION CROP

III. THE TIME FACTOR AND NEW SHOOT PRODUCTION

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and

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Introduction.—The time taken for a new shoot to develop to a stage at which it is ready for plucking is obviously of great importance in relation to the amount of crop which can be taken off a bush in any given period. This new shoot development time may be expected to depend both on the type of plucking practice adopted and on the condition, either flush or banji, of the shoot itself when plucked. Furthermore seasonal variations in climatic factors are likely to have an effect on shoot development times.

The present paper presents the results of series of field observations on shoot development times carried out on the same area of T.R.I. Clone No. 4 for which previous results have been reported in this series. (Portsmouth 1957a and b). These observations were carried out over the period December 1951 to October 1952 and cover the development of four successive sympodial shoots. The bushes used had been lightly pruned in November, 1950, on the completion of the previous experiment.

Definitions and Methods.—The normal plucking practice adopted in Ceylon has already been described in the general introduction to this series (Portsmouth 1957a). However, rather more rigorous definitions of the various terms used are now necessary for a proper interpretation of the present observations.

It was originally stated that plucking is carried out in such a manner as always to leave one mature leaf below the point of plucking. In actual practice the position of this mature leaf left on the bush is determined by the fact that it is accepted as being the next leaf above the fish leaf. Accordingly, for practical purposes, it is the position of this *fish* leaf which has to be rigorously defined. Bond (1945, p. 199) refers to the *fish* leaf as an appendage intermediate in growth rate between a scale and a foliage leaf. This explanation does not limit fish leaf characters to one appendage only and cases occur where there are two appendages intermediate in size between a scale and a true foliage leaf. Accordingly, to obviate any confusion on this account, the *fish* leaf of the plucker will be defined as *the first appendage showing foliar characters*, borne by the shoot above the last scale leaf. Where, therefore, the shoot carries two fish leaves, the lower and smaller of the two will determine the point of plucking, while the upper and larger will be accepted as the mature leaf to be left below the point of plucking. This leaf may accordingly be either the first true foliage leaf or else the larger of two fish leaves.

Crop shoots, as plucked, may be divided into flush and "banji" shoots. Flush shoots are shoots which are still in active growth at the time of plucking. The

accepted plucking standard is to take two open leaves and the terminal bud, so that flush shoots are ready for plucking as soon as there are three leaves, above the fish leaf, clear of the bud.

In banji shoots, on the other hand, active growth has often ceased before there are three leaves, above the fish leaf, clear of the bud. Although plucking such a banji shoot may only yield one leaf and a bud, it is the general practice to pluck these shoots immediately the terminal bud has become dormant and the shoot is still soft and suitable for manufacture. These shoots constitute what will be referred to as *tender banji*.

However, it is not always easy in the field for a plucker to determine that the terminal bud has become dormant, so that banji shoots are frequently left unplucked. Banji shoots left on the bush appear to mature rapidly with the consequence that, by the time of the next plucking, they have usually become too hard and coarse to be suitable for manufacture and, if plucked, have to be discarded. These shoots will be referred to as *coarse banji*.

When a crop shoot has been plucked, apical dominance is temporarily destroyed and the axilliary bud of the mature leaf left above the fish leaf generally develops into a new crop shoot. In some cases, however, new shoots may also develop from the axillary bud of the fish leaf or even from those of the scales. In the present series of observations all shoots developing from buds other than those subtended by the leaf above the fish leaf have been disregarded.

At the start of these observations, on 11-12-51, groups of 20 crop shoots which had reached the stage at which they were ready for plucking, were chosen, marked and plucked in each of the following conditions:—Flush, tender banji, coarse banji. A further group of 20 tender banji shoots was also chosen and marked, but left unplucked. The marked shoots were examined twice weekly and the dates at which the new crop shoots reached the following fixed points recorded:—

New flush shoots

(*a*) when the fish leaf first became clear of the bud.

(*b*) when the third leaf above the fish leaf first became clear of the bud.

New banji shoots

(*a*) when the fish leaf first became clear of the bud.

(*b*) when terminal bud activity was observed to have ceased and it was clear that the shoot had become a tender banji.

As soon as point (*b*) was reached the shoots were plucked, either as flush or tender banji, and the observations continued with the new shoots subsequently developed to a total of 4 successive shoots.

During these observations the unmarked crop shoots produced by the experimental bushes were regularly plucked at the normal 9 day intervals usual at the elevation of St. Coombs.

Results.—The times obtained from observations of the first batch of new crop shoots produced related to eight different conditions of new shoot development:—

(i) Flush shoots plucked to new pluckable flush shoots.
(ii) Flush shoots plucked to new pluckable banji shoots.
(iii) Tender banji shoots plucked to new pluckable flush shoots.

(iv) Tender banji shoots plucked to new pluckable tender banji shoots.
(v) Tender banji shoots left unplucked to new pluckable flush shoots.
(vi) Tender banji shoots left unplucked to new pluckable tender banji shoots.
(vii) Coarse banji shoots plucked to new pluckable flush shoots.
(viii) Coarse banji shoots plucked to new pluckable tender banji shoots.

For the second and subsequent periods the observations were combined as necessary and relate only to the conditions described in (i) to (iv) above, since all banji shoots produced were plucked as tender banjis.

(i) FLUSH SHOOTS PLUCKED TO NEW PLUCKABLE FLUSH SHOOTS.—The mean times, in days, recorded under this heading, together with their standard errors are given in Table 1.

Table 1. (i) *Flush shoots plucked to new pluckable flush shoots.*

(1) Period	(2) Season	(3) No. of Shoots	(4) Days to unfolding of FISH leaf (a)	(5) Days to unfolding of THIRD leaf (b)	(6) Mean interval (b) — (a) in days.	(7) Days for unfolding of one FOLIAGE leaf
1	Dec. 1951 to Feb. 1952	16	46.63 ± 1.50	74.56 ± 1.63	27.94 ± 1.19	9.31
			(6.70 ± 2.00)*	(2.63 ± 2.52)	(4.09 ± 1.53)*	
2	Feb. 1952 to May 1952	48	53.33 ± 1.33	77.19 ± 1.92	23.85 ± 0.96	7.95
			(1.31 ± 1.76)	(8.45 ± 2.53)*	(9.78 ± 1.94)*	
3	May 1952 to Aug. 1952	59	52.02 ± 1.15	85.64 ± 1.65	33.63 ± 1.68	11.21
			(4.24 ± 1.32)*	(4.76 ± 1.97)*	(9.01 ± 1.89)*	
4	Aug. 1952 to Oct. 1952	66	56.26 ± 0.65	80.88 ± 1.19	24.62 ± 0.87	8.21
1—4	Dec. 1951 to Oct. 1952	189	53.38 ± 0.59	80.89 ± 0.85	27.52 ± 0.69	9.17

In this and subsequent tables the figures given in brackets are the differences between the mean times recorded for any two successive periods. The standard errors of these differences have been calculated from the formula

$$SE_{1-2} = \sqrt{(SE_1)^2 + (SE_2)^2}$$

In accordance with convention, differences greater than twice their standard errors will be considered significant. Such significant differences are marked by asterisks.

The mean intervals between the two fixed points (*a*) and (*b*), which are given in column (6) of all tables, have been independently calculated from the intervals

recorded for each individual shoot and not by subtraction of the mean times given in column (4) from those given in column (5). The standard errors given in column (6) are, accordingly, specific to the mean intervals (*b*) — (*a*) and are independent of those given in columns (4) and (5).

In cases (i), (iii), (v) and (vii), where new flush shoots are developed, the mean interval given in column (6) is the time taken for the unfolding of the first three foliage leaves above the fish leaf. In such cases, therefore, the average time taken for the unfolding of one foliage leaf is directly ascertainable. This data is presented in column (7) of the tables.

Coming now to a more detailed consideration of the data of Table 1, it will be seen that, with only two exceptions, all seasonal differences in development times are obviously highly significant. This clearly indicates the existence of some climatic influence. Unfortunately, owing to the overlapping of individual observations, it is not possible to sharply delimit the different periods during which successive new shoots were produced. Accordingly, relevant meteorological averages for the four overlapping observational periods have been calculated and are presented in Table 2.

Table 2. *Meteorological averages—St. Coombs.*

(1) Period	(2) Season	(3) Mean monthly rainfall (inches)	(4) Mean daily sunshine (hrs.)	(5) Mean number of wet days per month.*
1	Dec. 1951 to Feb. 1952.	4.60	5.89	8.67
2	Feb. 1952 to May 1952.	10.24	6.05	14.25
3	May 1952 to Aug. 1952.	14.23	3.33	22.75
4	Aug. 1952 to Oct. 1952.	10.83	4.32	18.00

*Days on which more than 0.04" of rain fell.

Comparing the data of Table 2 with the times required for the unfolding of each successive foliage leaf, given in column (7) of Table 1, it will be seen that this time interval was least in period 2, February 1952 to May 1952, when sunshine hours were greatest and there was a monthly average of more than 10 inches of rain. Although rainfall was even higher during period 3, which was the period of the south west monsoon, sunshine hours were at their lowest and the time taken for the unfolding of each successive leaf was greatest. In period 1, on the other hand, although sunshine hours were ample, there would appear to have been insufficient rain to permit of rapid growth. In general, therefore, it would appear that the shoot growth rate, as measured by the unfolding of successive leaves, is dependant on both sunshine and rainfall.

Whilst there are also significant differences between successive periods in the times at which the fish leaf was first unfolded it is not possible to analyse this result further with the data available. This time interval, as recorded, includes two distinct physiological stages. Firstly an unknown number of days must elapse while the axilliary bud of the mature leaf left above the fish leaf is preparing itself to break into active growth. Secondly, once active growth has started, the young shoot may produce an unknown number of scale appendages before producing a fish leaf. The division between these stages being unknown it is obviously useless to speculate as to whether seasonal influences are operative on either or both of them.

(ii) FLUSH SHOOTS PLUCKED TO NEW PLUCKABLE BANJI SHOOTS.—The mean times in days, recorded under this heading, together with their standard errors are given in Table 3.

Table 3. (ii) *Flush shoots plucked to new pluckable banji shoots.*

(1) Period	(2) Season	(3) No. of Shoots	(4) Days to unfolding of FISH leaf (a)	(5) Days to pluckable BANJI (b)	(6) Mean interval (b) — (a) in days
1	Dec. 1951 to Feb. 1952	4	49.75 ± 3.71	75.00 ± 2.12	25.25 ± 1.70
			(10.75 ± 5.10)*	(1.00 ± 2.12)	(11.75 ± 3.89)*
2	Feb. 1952 to May 1952	2	60.50 ± 3.50	74.00 ± 0.00	13.50 ± 3.50
3		0	—	—	—
4		0	—	—	—
1—2	Dec. 1951 to May 1952	6	53.33 ± 3.38	74.67 ± 1.36	21.33 ± 2.85

Here again, although the table only covers the first two observation periods, the times given in columns (4) and (6) show significant differences between periods. The results accordingly confirm the existence of the seasonal effect demonstrated in the previous section.

(iii) TENDER BANJI SHOOTS PLUCKED TO NEW PLUCKABLE FLUSH SHOOTS.—The mean times, in days, recorded under this heading, together with their standard errors are given in Table 4.

Table 4. (iii) *Tender banji shoots plucked to new pluckable flush shoots.*

(1) Period	(2) Season	(3) No. of Shoots	(4) Days to unfolding of FISH leaf (a)	(5) Days to unfolding of THIRD leaf (b)	(6) Mean interval (b) — (a) in days	(7) Days for unfolding of one FOLIAGE leaf
1	Dec. 1951 to Feb. 1952	11	54.36 ± 3.43	83.09 ± 5.43	28.73 ± 2.99	9.58
			(1.91 ± 3.66)	(0.31 ± 6.01)	(1.60 ± 3.43)	
2	Feb. 1952 to May 1952	15	56.27 ± 1.30	83.40 ± 2.58	27.13 ± 1.67	9.04
			(3.14 ± 1.65)	(2.52 ± 3.10)	(0.62 ± 2.01)	
3	May 1952 to Aug. 1952	8	53.13 ± 1.03	80.88 ± 1.72	27.75 ± 1.11	9.25
4		0	—	—	—	—
1—3	Dec. 1951 to Aug. 1952	34	54.91 ± 1.25	82.71 ± 2.08	27.79 ± 1.21	9.27

There were no significant seasonal differences between periods.

(iv) TENDER BANJI SHOOTS PLUCKED TO NEW PLUCKABLE TENDER BANJI SHOOTS.—The mean times, in days, recorded under this heading, together with their standard errors are given in Table 5.

Table 5. (iv) *Tender banji shoots plucked to new pluckable tender banji shoots.*

(1) Period	(2) Season	(3) No. of Shoots	(4) Days to unfolding of FISH leaf (a)	(5) Days to pluckable BANJI (b)	(6) Mean interval (b) — (a) in days
1	Dec. 1951 to Feb. 1952	8	54.00 ± 2.77	80.75 ± 3.10	26.75 ± 1.46
			(2.20 ± 4.24)	(3.85 ± 4.50)	(1.65 ± 2.31)
2	Feb. 1952 to May 1952	10	51.80 ± 3.20	76.90 ± 3.26	25.10 ± 1.79
3		0	—	—	—
4		0	—	—	—
1—2	Dec. 1951 to May 1952	18	52.78 ± 2.12	78.61 ± 2.26	25.83 ± 1.17

Here again there were no significant differences between periods.

(v), (vi) TENDER BANJI SHOOTS LEFT UNPLUCKED. (vii), (viii) COARSE BANJI SHOOTS PLUCKED.—The various times, in days, recorded when either tender banji shoots were left unplucked or coarse banji shoots plucked are given in Table 6. The implications of these results will be considered in the discussion which follows.

Table 6. (v), (vi) *Tender banji shoots left unplucked.* (vii), (viii) *Coarse banji shoots plucked. Period* 1, *December* 1951 – *February* 1952.

(1) Initial treatment	(2) Type of shoot developed	(3) No. of shoots	(4) Days to unfolding of FISH leaf (a)	(5) Days to pluckable shoot (b)	(6) Mean interval (b) — (a) in days	(7) Days for unfolding of one FOLIAGE leaf
Tender banji left	Flush	15	59.13 ± 6.59	83.80 ± 6.28	24.67 ± 1.78	8.22
„ „ „	Tender banji	3	69.67 ± 8.33	102.33 ± 8.67	32.66 ± 0.33	—
Coarse banji plucked	Flush	8	46.88 ± 3.08	74.38 ± 1.68	27.50 ± 2.16	9.17
„ „ „	Tender banji	10	60.50 ± 3.74	87.70 ± 5.51	27.20 ± 2.99	—

Discussion and Conclusions.—The agricultural implications of the present results are best brought out by comparing the various times taken to produce new crop shoots, following different plucking treatments. However, in view of the seasonal effect which has already been demonstrated, it is obvious that any such comparison will only be valid if it is made during the same growth period. As period 1, December 1951 – February 1952, covered the widest range of different developmental conditions, the results for this period have accordingly been brought together and re-arranged in Table 7.

Table 7. *Summary of crop shoot development times. Period* 1, *December* 1951–*February* 1952.

(1) Type of shoot produced	(2) Initial treatment	(3) No. of shoots	(4) Days for development of pluckable shoot (b)	(5) Difference from general mean
Flush	Flush plucked	16	74.56 ± 1.63	— 6.63 ± 2.48*
,,	Tender banji plucked	11	83.09 ± 5.43	+ 1.90 ± 5.74
,,	Tender banji left	15	83.80 ± 6.28	+ 2.61 ± 6.55
,,	Coarse banji plucked	8	74.38 ± 1.68	— 6.81 ± 2.51*
Tender banji	Flush plucked	4	75.00 ± 2.12	— 6.19 ± 2.82*
,, ,,	Tender banji plucked	8	80.75 ± 3.10	— 0.44 ± 3.61
,, ,,	Tender banji left	3	102.33 ± 8.67	+ 21.14 ± 8.86*
,, ,,	Coarse banji plucked	10	87.70 ± 5.51	+ 6.51 ± 5.82
	ALL CROP SHOOTS	75	81.19 ± 1.86	

Combining all the observations for this period, it will be seen that the average time taken for a new pluckable crop shoot to be developed was 81.19 ± 1.86 days. The differences from this general mean, which are presented in column (5) of the table, should therefore serve to indicate whether or not a particular type of initial plucking treatment had accelerated the production of new crop shoots.

Considering first the plucking of flush shoots, it will be seen that, irrespective of the type of crop shoot subsequently produced, the average development times were both significantly less than the mean. As the remainder of the treatments all relate to the plucking or not plucking of banji shoots, it is obvious that when flush shoots were plucked there was a more rapid development of new crop shoots than when banji shoots were being dealt with. Accordingly, any cultural treatment which leads to an increase in the percentage of banji shoots produced must be avoided if maximum crops are to be secured.

Considering now the various initial banji treatments, it will be seen that there are only two cases which show significant differences from the general mean. In one case plucking of coarse banji has resulted in a more rapid production of new flush shoots, while in the other the leaving of tender banji unplucked has resulted in

a less rapid production of new pluckable tender banji. The implication of both these results is the same, namely, that all banji shoots should plucked without delay, if future reduction in crop is to be avoided. Furthermore, it is clearly most important for the planter to ensure that all banji shoots are plucked as tender banji, which is still suitable for manufacture, since, if they are allowed to remain on the bushes long enough to harden into coarse banji, they will have to be discarded as unsuitable for manufacture and crop will thus be lost.

The foregoing can be conveniently summarized in the statement that all crop shoots should be plucked immediately they have reached a state of readiness for plucking.

From Table 1 it will be seen that the average time interval between the unfolding of each successive foliage leaf, over the whole period of 11 months covered by the observations, was 9.17 ± 0.23 days. Table 4, however, which covers only the first three observational periods, gives the slightly higher figure of 9.27 ± 0.40 days, for this time interval. In view of the seasonal effect already demonstrated, this latter value is in accordance with expectation, since period 4, in which a shorter time interval could have been anticipated from the date of Tables 1 and 2, has not been taken into account.

It would thus appear reasonably correct to assume that the average time interval, over the full year, for the unfolding of successive foliage leaves does not differ appreciably from 9 days, which, as stated in the first paper of this series (Portsmouth 1957a) is the length of the interval between plucking rounds adopted by most planters on estates at this elevation. The present result accordingly affords further confirmation of the correctness of this plucking interval, since plucking rounds based on the time taken for the unfolding of one leaf will undoubtedly permit of the greatest proportion of the desired bud plus 2 leaf flush shoots being harvested.

The results presented earlier, however, indicate that this time interval does not remain constant throughout the year but varies to a considerable extent with seasonal changes in climatic factors. Used as a measure of shoot growth rate, the rate of unfolding of successive foliage leaves would appear to be dependant on the amounts of both sunshine and rainfall which are received during the given period of observation. Taken in conjunction with the fact that the weights of the individual flush shoots harvested are related to the amount of rainfall some two and a quarter months prior to plucking (Portsmouth 1957b), it would seem that much of the fluctuation in yield, which is observed on estates from month to month, is climatic in origin.

One further feature of the present observations requires comment. This is the almost complete disappearance of any new banji shoot production by the time the fourth period was reached. The increasing proportion of new flush shoots produced in each successive period can be clearly seen from column (3) of Table 1. This increase in the proportion of flush to banji shoots with time was, however, entirely contrary to ordinary field experience and requires further investigation. The fact that, in the course of these observations, some change in the environmental or other conditions of the marked shoots had occurred, which had tended to inhibit the early onset of dormancy, suggests that it may yet prove possible to devise methods of reducing the proportion of banji shoots formed under normal field conditions.

Summary.—The results of a series of observations on the times taken by T.R.I. Clone No. 4 to develop new crop shoots after plucking are presented and discussed.

During the period December 1951 to February 1952, which covered the maximum number of different plucking treatments, the average time taken for a new crop shoot to be developed was 81 days.

Differences in development times with different treatments indicate that all crop shoots should be plucked immediately they are ready, if maximum crops are to be secured.

Over the whole 11 months during which observations were carried out, the average time taken for the unfolding of successive foliage leaves was approximately 9 days, which corresponded with the plucking interval adopted by estates.

Shoot growth rate, as measured by the unfolding of successive leaves, was shown to be related to both sunshine and rainfall. Monthly fluctuations in yield thus appear to be largely climatic in origin.

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FACTORS AFFECTING SHOOT PRODUCTION IN TEA *(CAMELLIA SINENSIS)* WHEN GROWN AS A PLANTATION CROP

IV. INTER-CLONAL VARIATIONS IN THE EFFECTS OF APICAL DOMINANCE

G. B. Portsmouth

Introduction.—Apical dominance, or the inhibitary influence exerted by the terminal bud upon the axilliary buds of a shoot, is a factor which appears to have received no previous attention in connection with shoot production in tea. This is somewhat surprising when it is remembered that one of the primary objects of correct bush management on a plantation is to secure the maximum production of new sympodically developed crop shoots.

Although plucking, which consists in removing the terminal bud and one or more of the topmost leaves of the shoot (Portsmouth and Rajiah 1957), is an operation which temporarily destroys apical dominance, there are many occasions when the readiness with which lateral buds develop into new shoots can profoundly affect future crop shoot production and yield potential.

As soon as experience with the large scale propagation of tea clones by means of nodal cuttings began to accumulate it was apparent that marked differences existed in the numbers of lateral branches produced by different clones at the same stage of main stem development. Poorly branching clones invariably proved to be poor yielders and failure to branch freely at the nursery stage was early accepted as a sufficient reason for discarding a selection (Kehl, 1950). Many of the highest yielding Tea Research Institute selections are actually so freely branching as to require no frame forming treatment whatsoever before the young bushes can be cut across and brought into plucking for the first time.

Following a prune, the new primary shoots are allowed to develop unchecked for several months before they are broken back to a level, approximately two mature leaves above the pruning level, to form a plucking table. Here again the density and subsequent yielding capacity of the plucking surface is obviously dependant on the degree to which the primary shoots have been able to develop lateral branches prior to the breaking back operation.

Finally, apical dominance effects may well play a major part in determining whether only one new shoot or several new ones are developed to replace each plucked shoot.

Tubbs (1935) recorded separately the yields of one thousand bushes on St. Coombs, over a total of five pluckings, and found a ten-fold range of variation in individual bush yields. Whilst much of this variation is obviously due to external causes, there must undoubtedly remain a large range of yield variation between bushes which is solely due to differences in internal factors. More recent work, which is still in progress, using lines of clonal tea grown under much more rigorously controlled conditions, has shown that there is almost as wide a range of variation in

the yields per unit area of plucking surface of the different clones included in the experiment. These later results strongly confirm the contention that much of the observed variation in yield found by Tubbs is due to internal factors.

On the basis of the considerations outlined above it, therefore, seemed reasonable to suppose that apical dominance might be one of the internal factors concerned in shoot production in tea and of sufficient importance to warrant investigation.

It is now well known that the terminal bud exerts its inhibitory effect on the axilliary buds of the precedent nodes by producing one or more hormones which move downwards in the tissues of the shoot. Two lines of approach can, therefore, be adopted in investigating this phenomenon, either direct assay of the hormone production of the terminal buds themselves or observations of the extent of their inhibitory effects on lateral shoot development under controlled experimental conditions.

As no facilities for hormone assay existed at this Institute the latter method was of necessity adopted in the investigation now reported.

Materials and Methods.—When ready for plucking a flush shoot may be expected to comprise two scales, 1 fish leaf and 3 foliage leaves, making a total of 6 fully differentiated nodes. With such low node numbers available it appeared most unlikely that ordinary crop shoot material would permit of any valid assessments of the strength of apical dominance to be carried out. Work with such material was, therefore, temporarily abandoned during the present investigation and attention directed to the strongly growing primary shoots which are developed by the bush after a normal prune. Unless broken back to form a plucking table during the operation of "tipping" these primary shoots will continue in monopodial growth almost indefinitely, so that shoots comprising any required number of nodes are readily obtainable.

A small group of five adjoining well grown bushes, all originally planted out early in 1938, was selected for experimental purposes. The group contained one bush each of T.R.I. clones Nos. 2026, 2025, 2024, 2022 and 2011. These clones had all given very different yields in field trials and thus represented material in which it appeared possible that there might be considerable variations in apical dominance effects.

The bushes were all pruned down to the same level on 26-1-53 and the new primary shoots allowed to continue growing unchecked until an average of approximately 20 nodes per shoot had been produced. This condition appeared to be satisfied by 7-8-53, when observations were accordingly started.

Now, as briefly explained in the general introduction to this series of papers (Portsmouth 1957a), the cultural treatment meted out to tea is designed to produce a comparatively low growing type of bush with a wide expanse of level plucking surface. This peculiar frame formation undoubtedly influences the growth of the primary shoots produced after pruning, with the consequence that the centrally situated shoots develop more strongly and have longer internodes than those situated around the periphery of the bush. It is, of course, impossible to lay down any definite dividing line between these two types of shoots, but for convenience shoots selected near the centre of the bush (*central shoots*) will be treated separately from those selected towards the periphery (*side shoots*).

For each set of observations 20 central and 20 side shoots were selected at random on each bush. Three sets of observations were made in all on 7-8-53, on 28-9-53 and finally on 8-10-53.

Between the first and second set of observations the terminal bud and node below, bearing the latest unfolded leaf, was removed from all shoots on 15-8-53. The interval of 8 days between this operation and the first observation corresponded to the approximate time taken for one new foliage leaf to unfold at this time of year (Portsmouth and Rajiah 1957) and was thus equivalent to removing the terminal bud only at the time of the first observations. This operation was, however, deferred until the adequacy of the data collected had been assessed.

For the third set of observations the selected shoots were cut and brought into the laboratory for lateral shoots growth to be recorded. This procedure was necessary as it was found that the increase in the extent of lateral shoot development was so great as to render accurate recording impossible under field conditions at the time of the second observations.

Results.—(i) PRIMARY SHOOT GROWTH.—Data indicating the extent of the monopodial primary shoot growth, which had been developed by the date of the first observations, is presented in Table 1.

In the course of these observations the type of leaf borne by each main stem node was recorded. A succession of one or more scales followed by a fish leaf thus clearly indicated the existence of a *banji* period, during which the terminal bud had temporarily ceased to unfold and had assumed an outward appearance of dormancy. Having fixed this point the extent of the last period of uninterrupted growth was easily determined, the data being given in columns (7) and (8) of the table.

In passing it may be noted that it was not always possible to determine accurately the point of origin of some of the central shoots. The total number of nodes produced by these shoots was accordingly slightly indeterminate. This is indicated in the table.

The marked differences shown in the growth of the central and side shoots, together with the greater frequency with which the latter had gone banji, clearly confirmed the desirability of treating each group separately.

(ii) AXILLIARY BUD DEVELOPMENT.—The extent of axilliary bud development at the time of the first observations is shown in Table 2. The relevant standard errors are also included where applicable in both this and subsequent tables.

The explanations of the various terms used are:—

Node numbering. All primary shoot (main axis) nodes were numbered successively from the apex downwards, the node bearing the youngest leaf which was completely free of the terminal bud being designated Node No. 1.

Active buds. All axilliary buds which had at any time been in active growth were included in this category. Many of these buds had, of course, already developed into lateral branches at the time of observation. Axilliary buds, which had never broken their initial state of dormancy (dormant buds) or which were only just starting to break their initial dormancy (breaking buds), were not included.

Active shoots. Any shoot bearing one or more active buds was considered an active shoot.

Active zone. The expression active zone has been used in connection with any group of successive primary shoot nodes in which almost all the axilliary buds were either in active growth or breaking. In no case was such a zone allowed to be interrupted by more than one damaged or dormant bud. The zone was, of course, terminated at each end by active buds.

Table 1. *Primary shoot growth at* 7-8-53.

Clone No. (1)	Type of shoot (2)	Percentage showing banji periods (3)	Average number of times banji		Total nodes (6)	Average number of nodes in last growth period	
			Shoots with banji period (4)	All shoots (5)		Shoots with banji period (7)	All shoots (8)
2026	Central Side	55 100	1.00 2.50	0.55 2.50	> 21.05 18.40	> 17.00 7.10	> 18.15 7.10
2025	Central Side	60 100	1.58 2.15	0.95 2.15	> 22.50 19.45	> 9.58 8.25	> 13.75 8.25
2024	Central Side	50 85	1.40 1.59	0.70 1.35	> 22.05 20.30	> 16.80 10.47	> 18.40 11.85
2022	Central Side	20 85	1.00 1.76	0.20 1.50	> 22.05 20.90	> 19.00 11.35	> 19.60 12.65
2011	Central Side	70 100	1.14 2.10	0.80 2.10	> 18.75 17.75	> 16.43 8.65	> 17.40 8.65
Mean	Central Side	51 94	1.22 2.02	0.64 1.92	> 21.28 19.16	> 21.28 9.16	> 17.46 9.70

Table 2. *Axilliary bud development before removal of terminal buds. From observations made on* 7. 8. 53.

Clone No. (1)	Percent active shoots (2)	Total active buds per active shoot (3)	PARAMETERS OF LAST ACTIVE ZONE					
			Youngest active bud. Node No. (4)	Oldest active bud. Node No. (5)	Centre of zone. Node No. (6)	Extent of zone. Nodes (7)	No. of active buds (8)	Percentage activity of zone (9)
CENTRAL SHOOTS								
2026	50	5.00±0.87	8.60±0.67	13.20±0.84	10.90	5.60±0.95	5.00±0.87	89
2025	100	5.00±0.54	9.10±0.57	13.65±0.70	11.38	5.55±0.64	4.65±0.58	54
2024	100	7.55±0.69	6.95±0.25	13.50±0.79	10.23	7.55±0.74	7.45±0.73	99
2022	75	5.73±0.80	9.53±0.55	14.80±0.74	12.17	6.27±1.01	5.73±0.80	91
2011	25	2.80±0.80	8.80±2.35	10.40±2.23	9.60	2.60±0.93	2.40±0.75	92
SIDE SHOOTS								
2026	95	4.58±0.54	8.95±0.60	11.42±0.65	10.19	3.47±0.48	3.16±0.38	91
2025	100	5.25±0.75	7.70±0.64	10.90±0.77	9.30	4.20±0.78	3.35±0.48	80
2024	100	5.80±0.53	7.15±0.40	12.55±0.94	9.85	6.40±0.74	5.40±0.59	84
2022	90	5.22±0.58	8.50±0.59	12.28±0.67	10.39	4.78±0.64	4.11±0.53	86
2011	40	3.37±1.18	12.88±1.36	15.25±1.16	14.07	3.37±1.18	3.25±1.13	96

Table 3. *Axilliary bud development after removal of terminal buds. From observations made on* 28. 9. 53.

Clone No.	Percent active shoots (2)	Total active buds per active shoot (3)	PARAMETERS OF LAST ACTIVE ZONE					
			Youngest active bud. Node No. (4)	Oldest active bud. Node No. (5)	Centre of zone. Node No. (6)	Extent of zone. Nodes (7)	No. of active buds (8)	Percentage activity of zone (9)
CENTRAL SHOOTS								
2026	95	Not recorded	*1.42±0.23	*9.53±0.83	5.48	9.11±0.76	8.37±0.72	92
2025	100	,,	1.25±0.16	13.00±1.21	7.13	12.75±1.22	11.00±1.09	86
2024	100	,,	1.00±0.00	13.20±1.21	7.10	13.20±1.21	12.55±1.20	95
2022	100	,,	1.00±0.00	13.95±1.11	7.48	13.95±1.11	13.15±1.00	94
2011	85	,,	*2.06±0.47	*7.29±0.93	4.68	6.24±0.93	6.18±0.93	99
SIDE SHOOTS								
2026	90	,,	*2.28±0.59	*5.17±0.79	3.73	3.89±0.73	3.39±0.61	87
2025	100	,,	1.85±0.48	9.85±1.14	5.85	9.00±1.04	7.75±0.77	86
2024	100	,,	2.50±0.60	12.00±1.16	7.25	10.50±1.06	9.10±0.93	87
2022	100	,,	3.05±0.65	13.30±0.61	8.18	11.25±1.14	9.55±1.02	85
2011	40	,,	*3.50±1.45	*9.25±1.62	6.38	6.75±1.67	6.13±1.64	91

*New active zone developed after treatment.

Table 4. *Changes in axilliary bud development.*

Clone No. (1)	Percent increase in active shoots (2)	CHANGES IN PARAMETERS OF LAST ACTIVE ZONE						
		Youngest active bud. Nodes (3)	Oldest active bud. Nodes (4)	Centre of zone. Nodes (5)	Extent of zone. Nodes (6)	Percent increase in extent (7)	No. of active buds (8)	Percent increase in No. (9)
CENTRAL SHOOTS								
2026	+ 90	* — 7.18 ± 0.71	* — 3.67 ± 1.18	— 5.42	+ 3.51 ± 1.21	+ 63	+ 3.37 ± 1.13	+ 67
2025	Nil	— 7.85 ± 0.59	— 0.65 ± 1.40	— 4.25	+ 7.20 ± 1.38	+ 130	+ 6.35 ± 1.23	+ 137
2024	Nil	— 5.95 ± 0.25	— 0.30 ± 1.45	— 3.13	+ 5.65 ± 1.42	+ 75	+ 5.10 ± 1.41	+ 68
2022	+ 33	— 8.53 ± 0.55	— 0.85 ± 1.33	— 4.69	+ 7.68 ± 1.50	+ 122	+ 7.42 ± 1.28	+ 129
2011	+ 240	* — 6.74 ± 2.40	* — 3.11 ± 2.42	— 4.92	+ 3.64 ± 1.31	+ 140	+ 3.78 ± 1.20	+ 158
SIDE SHOOTS								
2026	— 5	* — 6.67 ± 0.84	* — 6.25 ± 1.02	— 6.46	+ 0.42 ± 0.87	+ 12	+ 0.23 ± 0.72	+ 7
2025	Nil	— 5.85 ± 0.80	— 1.05 ± 1.37	— 3.45	+ 4.80 ± 1.30	+ 114	— 4.40 ± 0.91	+ 131
2024	Nil	— 4.65 ± 0.72	— 0.55 ± 1.50	— 2.60	+ 4.10 ± 1.29	+ 64	+ 3.70 ± 1.10	+ 69
2022	+ 11	— 5.45 ± 0.88	+ 1.02 ± 0.91	— 2.21	+ 6.47 ± 1.31	+ 135	+ 5.44 ± 1.15	+ 132
2011	Nil	* — 9.38 ± 1.99	* — 6.00 ± 2.00	— 7.69	+ 3.38 ± 2.04	+ 100	— 2.88 ± 1.99	+ 89

* New active zone developed after treatment.

Table 5. *Lateral branch development. From observations made on* 7. 8. 53 *and* 8. 10. 53.

Clone No. (1)	No. of primary shoot nodes compared (2)	Mean No. of Lateral branch nodes developed at each Primary shoot node		Increase (5)	Percentage increase (6)
		Before removal of terminal buds (3)	After removal of terminal buds (4)		
CENTRAL SHOOTS					
2026	15	0.51 ± 0.14	3.05 ± 0.36	+ 2.54 ± 0.39	+ 498
2025	20	0.89 ± 0.15	4.68 ± 0.26	+ 3.79 ± 0.30	+ 426
2024	17	1.67 ± 0.31	4.08 ± 0.33	+ 2.41 ± 0.45	+ 144
2022	16	1.28 ± 0.34	6.34 ± 0.45	+ 5.06 ± 0.56	+ 395
2011	14	0.14 ± 0.04	1.53 ± 0.23	+ 1.39 ± 0.31	+ 993
SIDE SHOOTS					
2026	14	0.80 ± 0.25	1.44 ± 0.17	+ 0.64 ± 0.30	+ 80
2025	13	0.85 ± 0.18	3.20 ± 0.22	+ 2.35 ± 0.29	+ 276
2024	14	1.07 ± 0.25	3.03 ± 0.14	+ 1.96 ± 0.28	+ 183
2022	17	0.91 ± 0.16	2.29 ± 0.11	+ 1.38 ± 0.20	+ 152
2011	13	0.14 ± 0.06	0.78 ± 0.13	+ 0.64 ± 0.14	+ 457

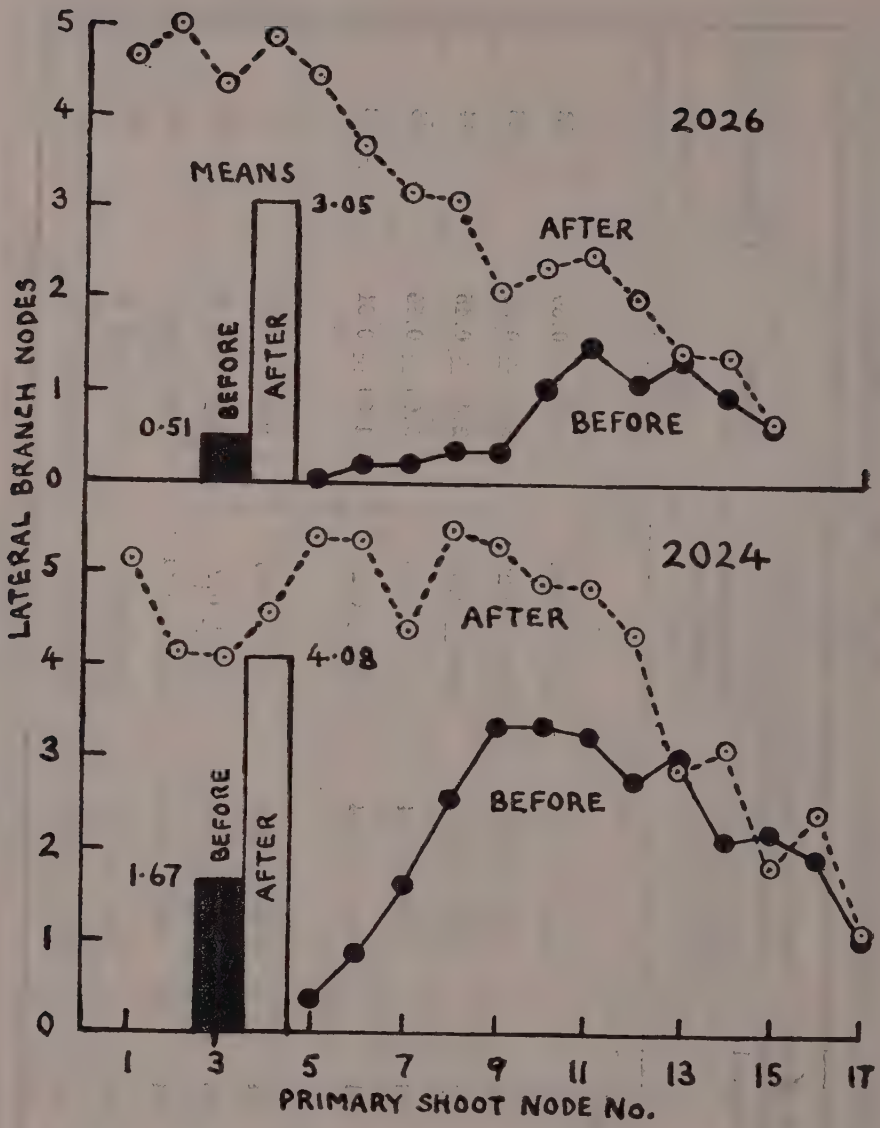

Figure 1. Diagram showing the extent of lateral branch development of the central shoots of clones Nos. 2024 and 2026, both before and after terminal bud removal. The data have been reduced to a single shoot basis.

The last active zone, for which parameters are given in the tables, was thus the zone of continuous axilliary bud activity closest to the apex.

From Table 2 it is obvious that, under conditions of unrestricted monopodial growth, marked and significant differences existed between the various clones, both in respect of the proportions of shoots exhibiting axilliary bud activity and in respect of the position and extent of such activity.

The removal of the terminal buds on 15-8-53 greatly stimulated axilliary bud activity, as is evident from the data, recorded at the time of the second observations, presented in Table 3.

In the case of the less active clones, Nos. 2026, 2022, and 2011, the proportions of active shoots in the samples show a general increase, whilst the extent and closeness to the apex of the last active zone has greatly increased in all cases. In clones Nos. 2025, 2024 and 2022 these latter effects were obviously the result of an extension of the old last active zone, but in clones Nos. 2026 and 2011 an entirely new active zone appears to have been developed in closer proximity to the apex.

The extent of the changes which occurred in the various parameters recorded are shown in Table 4.

Considering these results in detail it will be seen first that all the changes produced in the positions of the youngest active bud, given in column (3) of the table, are obviously highly significant. Furthermore it is probably not unreasonable to suggest that the relative magnitudes of these particular changes provide a good measure of the relative strengths of apical dominance effects in the different clones. This is a point which will be considered further in the discussion.

The changes recorded in columns (6) and (8) of the table are also all highly significant except in the case of clones Nos. 2026 and 2011. This result was to be expected in view of the fact that, as stated previously, these two clones had apparently developed entirely new active zones.

Further confirmation of this presumed development of new active zones is afforded by the data recorded in column (4), since the only significant changes in the position of the oldest active bud are those shown by clones Nos. 2026 and 2011.

(iii) Lateral branch development.—Some idea of the changes in lateral branch development induced by terminal bud removal can be obtained from Figure 1, in which data for the central shoots of a good clone No. 2024, and a poor clone, No. 2026, are shown diagrammatically. The means given on the diagram cover the whole range of primary shoot nodes used for comparison purposes and are the same as those given in columns (3) and (4) of Table 5, in which lateral branch development data for all the different clones is summarized.

As figures for all the 20 shoots in each sample have been utilised, the range of primary shoot nodes, from node No. 1 downwards, which has been used for comparison purposes varies somewhat from clone to clone, since it was of necessity restricted to the maximal number of nodes common to every shoot in each pair of samples. Details of these ranges are given in column (2) of the table.

Finally it may be noted that the increases in lateral branch development following terminal bud removal, shown in column (5) of the table, are all obviously highly significant.

Discussion and Conclusions.—Before considering the implications of the results reported in the previous section a knowledge of the relative yields of the five clones used is necessary. Calculated yields expressed as pounds made tea per acre, secured during the first three years of plucking, from test lines growing under identical conditions, are accordingly presented in Table 6.

Table 6. *Clonal Yields.*

Clone No. (1)	Calculated Yields as lbs/acre made tea				
	1st year (2)	2nd year (3)	3rd year (4)	Average (5)	Order of merit (6)
2026	380	1120	1780	1093	4
2025	745	1830	2310	1628	2
2024	1240	2295	2655	2063	1
2022	860	1650	1535	1348	3
2011	460	925	1285	890	5

Based on yield alone the order of merit of these clones is Nos. 2024, 2025, 2022, 2026 and 2011; an order which is clearly strongly correlated with many of the parameters and changes recorded in the preceding tables.

Considering first the data of Table 2, strong indications of this order can be seen in:—

(1) The percentages of active shoots per sample. Combining the figures for central and side shoots in column (2) of the table gives No. 2024 = No. 2025 = 100%, No. 2022 = 82.5%, No. 2026 = 72.5% and No. 2011 = 32.5%, which is in complete agreement with the yield order.

(2) The total numbers of active buds per active shoot and per last active zone. In both cases clone No. 2024 shows the highest figures and clone No. 2011 the lowest.

(3) The nodal position of the youngest active bud. Here again clone No. 2024 shows the smallest node number and clone No. 2011 the highest.

All the above characteristics are ones which are presumably largely conditioned by apical dominance effects and the results thus provide strong support for the contention that apical dominance is a factor of considerable importance in shoot production.

However, the figures for the total numbers of active buds per bush, for the complete sample of 40 shoots, are probably of most interest in this connection, since this method of presentation combines both the numbers of active shoots and the numbers of active buds per shoot. These figures, both before and after the removal of the terminal buds, and their correlations with yields are accordingly given in Table 7.

Table 7. *Clonal yields and numbers of active buds per sample of 40 shoots.*

Clone No. (1)	Annual Yield lbs/acre (3 yr. average) (2)	Before removal of terminal buds: Total of all active buds (3)	Before removal of terminal buds: Total active buds in last zone (4)	After removal of terminal buds: Total active buds in last zone (5)
2026	1093	137	110	220
2025	1628	205	160	375
2024	2063	267	257	433
2022	1348	180	160	454
2011	890	41	38	154
Correlations with Yield		+ 0.9522*	+ 0.9636**	+ 0.7970

Significance levels where n = 3

	P	r
**	.01	0.9587
*	.02	0.9343
	.05	0.8783

Both sets of correlations of active bud number, calculated from the figures obtained before the removal of the terminal buds, are as highly significant as could be expected with such a small number of values. This fact, together with the fact, that the correlation obtained after the removal of the terminal buds is not significant is most interesting, since it suggests that the operation of plucking, equivalent to terminal bud removal, can have little or no influence on inherent yield.

Taking $r = + 0.9636$ from column (4) of Table 7, as being the more accurate of the two estimates of the correlation coefficient obtained before terminal bud removal, gives a regression of yield (y) on active bud number (x): $y = 601 + 5.54x$ lbs/acre/annum. Using the formula $SD_r = \sqrt{\frac{S(y-\bar{y})^2}{n-2}} \sqrt{1-r^2}$, as an estimate of the standard deviation of the differences between actual and predicted values, gives $SD_r = 10.13\%$ of y, indicating that potential yield can be predicted with an accuracy of about $\pm$ 10 per cent by this means.

If substantiated, this finding should prove of considerable importance, since it offers a means of making useful yield comparisons between clones without the necessity for maintaining continuous plucking records over several years. All that is required is to cut all the bushes across at the same time, allow the new primary shoots to develop unchecked for about 6 months, and then carry out the appropriate count of active buds on a sample of shoots from each bush.

The data for active bud number discussed above show that terminal bud removal has brought about a marked reduction in the recorded differences between clones. This can also be seen from Table 3, in which the differences between the various parameters recorded, for clones Nos. 2025, 2024 and 2022, in all columns are almost entirely non-significant. Clones Nos. 2026 and 2011 must, however, be excluded from the argument, since, as explained previously, terminal bud removal has brought about the development of new active zones.

In order for this greater uniformity of recorded parameters to have resulted from terminal bud removal it is necessary for the greatest changes to have occurred in the poorest clones and vice versa; *i.e.* the magnitudes of these changes should display an inverse relation with yield order. That this is indeed the case can be seen from Table 4, in which the relative order of change in almost all the parameters recorded is first clone No. 2022, then No. 2025 and finally No. 2024.

A somewhat similar inverse relationship is apparent in connection with the changes in lateral branch development recorded in Table 5. This is most readily perceived if the percentage increases in the mean numbers of lateral branch nodes, given in column (6) of the table, are studied.

All these inverse relationships strongly confirm the previously expressed contention that the operation of plucking, although it must temporarily destroy apical dominance, has little or no effect on the yield potential that can be realised by any particular clone. Yield potential would thus appear to be an inherent characteristic which is inversely correlated with the degree of apical dominance exerted by the terminal bud of an actively growing shoot, the strength of such apical dominance being measured by its effect on axilliary bud development. Furthermore none of the cultural operations at present employed in bringing a bush into bearing appear capable of neutralising these apical dominance effects. The practice of discarding a poorly branching selection at the nursery stage would therefore appear to be fully justified.

Acknowledgement.—The invaluable co-operation of Messrs. F. H. Kehl and E. S. Rajiah is once again gratefully acknowledged.

Summary.—The results of observations on the amount of axilliary bud development, both before and after terminal bud removal, shown by the primary shoots of five different T.R.I. clones which had been allowed to develop unchecked for over six months, are presented and discussed.

Prior to terminal bud removal, a highly significant correlation between the numbers of active axilliary buds developed and the relative yields of the different clones has been shown to exist. The calculated regression of yield on active axilliary bud number indicates that the adoption of a suitable sampling technique, involving counts of active buds, can be used to predict potential clonal yields with an accuracy of about $\pm$ 10 per cent.

It is suggested that this relationship owes its origin to the fact that the observed differences in clonal yield potential are largely inherent and are inversely proportional to the strengths of the apical dominance effects exerted by the terminal buds.

Following terminal bud removal there was a marked levelling up in the various parameters recorded and the correlations with yield disappeared. This suggests that neither the operation of plucking which, like terminal bud removal, must temporarily destroy apical dominance, nor any of the normal cultural operations can have much effect on inherent yield potential.

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*ASPECTS OF REPLANTING

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One of the most important aspects to be considered in planning replanting of tea is perhaps the problem of deciding how much of the land is unsuitable for cultivation of tea and should instead be reafforested. The purpose of this article is to suggest that it would be wise to adopt a liberal policy of re-afforestation.

First, there is the very obvious reason that nearly every estate has areas which should never have been opened in tea because of unsuitable soil or steepness of the terrain. Such areas may well total 10 per cent of the cultivated acreage on the average Ceylon mid and upcountry estate. In addition there are marginal areas which might respond to intensive soil re-conditioning.

Let us however consider two important factors which have an indirect bearing on the subject, and are therefore not so obvious at first sight. The first of these is the agricultural consequence of doubling, or even trebling, yields by replanting with selective clonal material, while the second is the economic consequence on the world market.

Agricultural Aspect.—Fertiliser application will have to be increased to maintain sufficient N.P.K. "reserves", while at the same time healthy soil condition must be maintained by adequate supplies of green manure. The denser cover of tea will help to a great extent, but it is doubtful, even with normal loppings from shade trees, whether this would be sufficient. The aim should be to build up a thick carpet of continuously decaying vegetable matter, in the same manner that Nature maintains soil fertility in wet tropical forest. This can only be accomplished if, at the time of replanting, ample thatching material is grown in areas situated sufficiently near the tea to avoid heavy cost of transport. It is suggested that a minimum of 25 per cent of the old tea area should be set aside in convenient blocks, or wide contour bands between fields, in which timber and fuel trees as well as green manure grasses could be grown. To facilitate transport of thatching material into the tea rows it would be preferable to establish these reservations on each side of lead-off drains. The new contour rows of tea will eventually develop into almost impenetrable hedges. Thatching material will therefore have to be taken along the rows from the lead-off drains. Reservations about 30 feet wide on each side of these drains would obviously be the most convenient layout for this purpose.

Let us pause for a moment to consider the benefit to be derived from establishing a carpet of decaying vegetation below the cover of the tea. There would be a slow but continuous process of building up new soil. Consequent on improvement in soil structure and its micro-biological activity, nitrification would be accelerated. It may well be found that the present recommended minimum fertiliser rate of 8 pounds nitrogen to 100 pounds of crop could be lowered, and that inorganics could be regarded more in the nature of an activator for the decomposition of vegetable matter.

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* The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the staff.

Another vital benefit would be the elimination of weeds by smothering. Instead of weeders being employed to scrape soil down the hillsides they would be spending their time thatching green manure obtained from the blocks. Tests carried out in 1-acre blocks have shown that a 4 inch deep thatch of mana grass in old tea needs only 1 labourer per acre per month over the six months following the thatching to keep weeds under control. If in addition there is a dense cover of tea, and a fresh layer of mulch spread every six months or so, there would no longer be any weed problem. It would indeed be a happy day for Ceylon if all scrapers could be dumped in the Indian Ocean.

Economic Aspect.—Let us take a property of 120 acres of which 100 acres is tea, 10 acres buildings, roads etc., and 10 acres scrub and forest, the average up-country estate in miniature. We are getting 800 pounds per acre, at a C.O.P. of Rs. 1.60. We are satisfied that replanting with proved clonal material will produce a yield of 2000 pounds per acre. Being progressive we decide on a long-term policy of replanting annually 5 per cent of our tea area, *i.e.* 5 acres. After a survey of the 100 acres it is decided that 10 acres are definitely unsuitable for tea and should be re-afforested as a timber and green manure reserve. There is a further 10 acres of marginal land, at present giving about 600 pounds per acre, which could, we consider, with replanting yield 1200 pounds per acre. However, we decide this area would be more valuable as a timber, fuel, and green manure reserve. This leaves 80 acres of the best land, which we wish divided into 5 fields of approximately 15 acres each. In order to shape off our timber and green manure reserves in convenient blocks, or contour bands between each field, it is decided to appropriate a further 5 acres for this purpose, finally leaving 75 acres for replanting at 5 acres per year.

For the sake of comparison we have to assess the worth of our property before and after replanting in terms of present day values:—

1. Before Replanting:—
   100 acres @ 800 lb. per acre = 80,000 lb. made tea @ C.O.P. Rs. 1/60
   Profit at Rs. 2/- per lb. Market Average . . . . . Rs. 32,000/-

2. After Replanting:—
   75 acres @ 2000 lb. per acre = 150,000 lb. made tea @ C.O.P. Rs. 1/20
   Profit at Rs. 2/- per lb. Market Average Rs. 120,000/-

There are already indications that yields of well over 2000 pounds per acre may be obtained from first class clonal material, but a conservative figure has purposely been used in this comparative assessment. To assess the C.O.P. for a yield of 2000 pounds per acre calculation was made from actual costs of an estate yielding 800 pounds per acre, which revealed a reduction in C.O.P. of over 40 cents per pound had a yield of 2000 pounds per acre been obtained, assuming proportional increase in fertiliser. This is in fact a very conservative assessment of the increase in profit which would occur if, by the wave of a magic wand, 100 acres yielding 800 pounds per acre be overnight transformed into 75 acres yielding 2000 pounds per acre.

No account has however been made for the capital expenditure which would be required for extra accommodation for increased labour requirements, and factory expansion.

Whether world consumption of tea will progress sufficiently to absorb the potential increase in production is a matter of speculation. Even by converting 75 per cent of Ceylon's present tea acreage into high yielding clonal stock annual output could be doubled. Spread over many years conversion will, however, be very gradual.

The question of matching supply to demand leads one to speculate on whether it would not be prudent to convert even more than 25 per cent of our old tea into timber and pasture. At lower elevations cocoa, spices, etc. could be considered. Might it not be better agricultural economy to utilise at least one third of the land for other products thereby maintaining a more balanced economy. It will be noted that in the assessment of the income from our 100 acre estate no profit from the 25 acres in timber and fuel trees has been included, yet the potential value of produce from this area would be considerable, apart from reducing our dependence on oil for fuel.

Finally it must be borne in mind that land used for other produce can always be reconverted into tea should a strong world demand for this commodity persist in spite of increased production. Provided the land were suitably cultivated over a period of 20 to 25 years the fertility of the soil would improve, with benefit to the tea which may subsequently be planted.

Summary.—It is suggested that between one quarter to one third of our present tea areas should be utilised for cultivation of timber, fuel, green manure and other products when replanting is carried out. This will require a careful survey and planning ahead as if a new estate were being opened up. Blocks, or wide contour bands between each new field, would facilitate transport of green manure for thatching in the tea.

Benefits to be derived from this part-reafforestation and cultivation of "other products" are:

1. Establishment of much needed timber and fuel reserves.

2. Ample green manure for thatching in the tea for improvement of tilth and elimination of weeds.

3. Soil improvement from a period under other products.

4. Adequate wind breaks.

5. Improved water retention which, together with improved tilth, will reduce effects of drought.

6. Exercise of control measures against over-production of tea.

7. The cultivation of "other products" would give a better agricultural and economic balance.

Now is the golden opportunity to plan ahead when replanting is in its infancy.

*OBSERVATIONS ON MITE ATTACKS IN HAPUTALE

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Past Observations and Weather.—Tea mites have been observed in the past in isolated patches, but prior to 1956 had never given cause for alarm. They had usually become noticeable during the months of July and August, but with N.E. rains normally falling in September, a natural form of control had been effected, and little or no harm to the tea had occurred.

Yellow mite and red spider had both been readily detected, but scarlet and purple mite, both of which live on the underside of the leaf, may well have been present in small numbers but gone unnoticed.

Rainfall for the 6 months period December 1955 to May 1956 was the lowest since records were first kept on this estate 61 years ago. Rainfall for the first five months of the year was 14.19 inches, some 30 inches below the decennial average; the number of wet days was 44, 35 days short of the decennial average. Rainfall during the normally dry period June to September was slightly above average, which, although having no direct bearing on the natural control of mite attacks, did hasten the recovery of debilitated bushes.

Observations in 1956.—Purple and scarlet mites were first noticed about the middle of May, on scattered bushes, and soon became prolific in two widely separated areas in the lower part of the estate. The soil in these two areas is generally poor and mainly gravel, and it would appear that, even if mites were present throughout the rest of the estate, the poor water holding property of this soil resulted in uneven competition with the sucking action of the mites, and the damage caused in the early days of the attack was more conspicuous than in other parts of the estate.

By the beginning of June, scarlet and purple mite had become active to one degree or another throughout all fields below an elevation of about 5,000 feet. In the first instance, fields between 1 and 2 years from pruning were worst affected, but later mites were to be found on tea of all ages, including some only 6 months from pruning.

Yellow mite infestation became heavy by about the middle of June, but was confined mainly to young fields of a year old or younger.

Red spider was noticed on isolated bushes early in June and concentrations became heavy in patches in both young and old fields by August.

Control Measures.—Tea in plucking.—Spraying of the two worst affected areas, within which considerable defoliation was taking place, was started in June using "Thiovit", a tainting acaricide. Three applications were given at weekly intervals, and retipping started 3 weeks after the final application.

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Other areas, in which attacks developed at a later date, were treated before defoliation occurred with 3 rounds of "Akar" spray. This acaricide, being non-tainting, the sprayed areas were kept in the plucking round, spraying taking place within one or two days after plucking.

The results of both types of acaricide treatment were excellent, and no living mites were detected in the treated areas shortly after the final spraying round. The tea treated with the tainting acaricide, however, now presents a fuller appearance due no doubt to the benefit derived from the enforced rest.

At the beginning of September a young field, 9 months from pruning, became heavily infested with yellow mite and red spider. "Akar" being non-effective against yellow mite, one round of "Thiovit" spraying was carried out, at double the normal concentration, followed by a 3 weeks' rest. Results were excellent and this method of control would appear to be warranted if yellow mite attacks become severe towards the end of the dry season with reasonable prospects of rain to provide further control.

For both types of acaricide 100 gallons of liquid per acre per round were sprayed.

PRUNED TEA.—One field, pruned in July, was heavily infested with scarlet mite before pruning. After the prunings had dried off, this field was sprayed with "Thiovit", at 40 gallons of liquid per acre for three rounds, particular attention being paid to the maintenance foliage left on the bush after pruning. It is hoped that pruned tea so treated will be comparatively free from mite attacks for 3 years or more.

Method of Spray Application.—Normal single jet blister spraying equipment was used, the spray being applied on the lines indicated in the *Tea Quarterly* of December, 1955. Sprayers were charged by a motor charge pump.

Costs.—TEA IN PLUCKING.—

"Thiovit" spraying (tainting)

4 lbs. "Thiovit" per acre @ -/88	...	3.52
Labour—2.3 labourers per acre	...	5.87
		9.39
Cost per acre for 3 rounds	... Rs.	28.17

"Akar" spraying (non-tainting)

1/10 gallon "Akar" per acre @ 7/80	...	7.80
Labour—2.3 labourers per acre	...	5.87
		13.67
Cost per acre for 3 rounds	... Rs.	41.01

PRUNED TEA.—

"Thiovit" spraying.

4 lbs. "Thiovit" per acre @ -/88	...	3.52
Labour—1 labourer per acre	...	2.50
		6.02
Cost per acre for 3 rounds ...	... Rs.	18.06

The labour costs are the average for a total of 94 acres sprayed, but varied in each field, according to the availability of water. The use of hand charge pumps would undoubtedly increase the labour costs above the figures shown.

The choice of the type of acaricide to be used must rest on the extent to which the mite attack has developed. If defoliation has occurred on a large scale, then resting is advisable and the cheaper "Thiovit" is the obvious choice. The use of "Akar" would be preferred if defoliation has not occurred to any extent, the extra cost of the material being offset by the crop harvested.

The limiting factor to the extent of control measures that can be taken is the availability of water. On this estate many springs had dried up by the end of May for the first time in living memory. The volume of water required being over six times the amount required for blister protection, the acreage sprayed was limited to those areas in which water was to be found in sufficient quantity.

Shade and Green Manure Trees.—Scarlet mites were found in small numbers on some pollarded Albizzias, and normal lopping was found to be sufficient for control.

Larger mite populations were, however, present on Grevilleas. There does not appear to be any really effective answer to mite control on tall shade which is normally left unlopped, but as a compromise all branches below 12 feet have been removed in areas known to be infested.

Future Control.—Mite attacks in 1956 have necessitated some alterations to the pruning programme. One field, heavily infested with scarlet and purple mite and scheduled to come down in June 1957, has been advanced to January with the object of eliminating the mite population before weather conditions become favourable for a further build up.

All fields below 5,000 feet, due to be pruned in 1957, are to be sprayed with "Thiovit" after pruning, and allowance has been made in the estimates for the treatment of up to 50 acres of tea in plucking, should this be required later in the year.

An examination of defoliated bushes in an untreated area was made during the first week of January 1957, and many heavy concentrations of scarlet mite were found. The worst of the north east monsoon weather is normally past by this time, and, should weather conditions similar to the early part of 1956 recur, it is reasonable to expect further mite attacks during 1957.

It is open to conjecture whether or not spraying for the control of mites will become a routine measure in the future, as for blister blight, until such time as the vulnerable acreage has acquired the necessary immunity as a result of post pruning treatment.

SOIL CONSERVATION UNDER THE PLANTATION SYSTEM OF TEA CULTIVATION IN CEYLON*

J. A. H. Tolhurst

A visitor to Ceylon is bound to be impressed by the turbulent slopes which form so much of the landscape, and also by the rain which hurls itself upon the hills. A visitor who is also a soil scientist will be still more impressed when he sees the tea plantations with their apparent attraction for the steepest and wettest districts. He will notice at once the original, and now illegal, practice of planting in neat rows running straight up and down even the steepest slopes, and he will immediately remember his preconceived ideas on soil erosion and will wonder just what equilibrium has been reached between the tea bush and the top soil. Let us hope that our hypothetical visitor will find the energy to push his way through some of the vigorous plantation tea and examine the soil. It will give him plenty to think about.

Those were my first impressions a few years ago, and nothing which I have since seen in the tea plantations has caused me to believe that soil erosion there is, or need be, a serious problem provided that certain basic agricultural principles are followed.

Tea, being a woody perennial which forms a rigid stem and root system early in its life, affords an excellent measure of the degree of soil movement. There are also many examples of varied planting conditions: tea following jungle, or rubber, or coffee, and so forth. Some of the present tea itself was planted eighty years ago, and some is on land which has been under the plantation system of cultivation for over a century. What is the general picture of soil erosion under such varied conditions?

The answer is quite simply, that very little soil movement has occurred. There is a little banking up on the upper sides of the bushes, and a little hollowing at the base of the stem on the lower side. These effects may be more pronounced at mid-country elevations, as I shall mention later, but such movements do not necessarily mean that soil has actually left the hillside at all. To a large extent they represent local re-distribution between the individual tea bushes.

I can imagine that some of you are preparing to disagree with this last statement, possibly on the basis of an argument which has common currency in Ceylon. This argues that the colour of the main rivers after heavy rains is due to soil erosion from the hills, and therefore from cultivated areas. I should like to do my best to persuade you that this is based on careless observation and faulty interpretation. Any study of rivers should start at their source, and since our two largest river systems spring from areas which are largely planted in tea I have been able to draw some conclusions as to the origin of turbidity in the rivers.

It is notable that fast running mountain streams, draining large areas of tea, are usually very clear, and that only after a prolonged dry spell is there a cloudiness in the first rush of water. These clear streams can usually be followed down until they come into contact with drainage from roads, or building sites, and it is there that the real turbidity begins.

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* Address given before Section B of the Ceylon Association for the Advancement of Science on the 23rd November, 1956.

That, I suggest, represents by far the most important source of soil in the rivers, and observation of the streams issuing from tea land agrees very well with observation of the tea land itself. There is, however, another source of turbidity in river water, namely ferric hydroxide, and this certainly does come from tea soils. Perfectly clear spring water will precipitate ferric hydroxide on standing, either in the laboratory or in the sluggish waters of pools and marshes. This deposit, on rocks or on water weeds, is very fragile and is easily washed off by turbulent water.

It would be interesting to know how much of the initial turbidity which we see in rivers after heavy storms is due to the stirred up iron deposits, and also how much more ferric hydroxide precipitates by the time the mountain waters are swirling through the low country. This, of course, is an integral part of soil formation, and has nothing to do with soil erosion.

I have gone into these points in some detail, and with some emphasis, because the Tea Research Institute bases its recommendations for management on the assumption that many years of practice have demonstrated that the tea bush can act as an excellent soil conserver, and that this conservation is best achieved by just those practices which favour the most efficient production of the tea crop. So far I have concentrated on observations and their interpretation, but I can support some of my contentions with actual analyses, which in themselves may be of interest outside the subject of soil conservation.

Everyone knows what soil fertility is, although no one can define it, but possibly the most important single component is the organic matter status. I have just completed an extensive survey of tea soils and, wherever possible, the adjoining jungle soils, covering all the areas under tea in Ceylon, from sea level to the heights of Nuwara Eliya, and from the deluges of Dolosbage to the comparatively dry bowl of Uva. I deliberately took my samples from the most varied conditions I could see, with the proviso that the tea was grown under plantation management. Arising from the results of the organic matter analyses are some relations which seem to have a bearing on the practical management of tea as a soil conserving crop.

The jungle soils, in the top six inch layer, and also in the second six inch layer, show a steady and linear increase in organic matter with a rise in elevation. Up to three thousand feet the points fall very closely on the line, but above this point the scatter is great. The tea soils, however, show a very different pattern. Up to three thousand feet there is little changes in the organic matter, with the exception of a most unexpected decrease between two and three thousand feet. This, although slight, is nevertheless real. At the higher elevations the organic matter increases rapidly, and shows a similar scatter to the jungle soils.

At the lowest and at the highest elevations there is very little difference in organic matter between jungle and tea soil, but in the mid-country the difference is at its greatest. To take this a step further, I have taken profile samples from selected areas, and we have a fairly clear picture of the organic matter distribution down the profile. This can help to decide whether the present top soil in the tea fields, which I have just been considering, is the original top soil depleted of organic matter, or the original sub soil which has now come to the surface through erosion. No cultivations practised in tea plantations could ever invert the soil layers.

I am convinced from the analyses that in the majority of areas the present top soil under tea is the original soil with very little mechanical loss. In the mid-country zone, where the organic matter is unexpectedly low, it seems that the high rate of decomposition of the organic matter has been accompanied by more erosion than at elevations above or below. More erosion, certainly, but still not very much. When you remember that the chemical analyses include raw organic matter, which is impossible to exclude entirely from the samples, and that the jungle soil has the

greater proportion of this, you will see that I have deliberately understated the evidence in favour of soil conservation.

Organic matter as such is a well known soil stabiliser, whether by virtue of its physical buffering action when present on the surface as a mulch, or by reason of chemical interaction within the soil to produce stable aggregate units. It was a logical step to follow the organic matter survey by physical analyses of the water stability of aggregates, and this is being done now. If I comment on some of the preliminary trends of this work I must ask you to remember that they are only tentative comments.

It does not seem as though there will be a very close correlation between organic matter and water stability of aggregation, as measured by the usual wet sieving of fresh soil on a bank of sieves, and correcting for stones. However, the breakdown of aggregates by air drying the soil and then sieving under water is lessened where the organic matter is highest. The low organic mid-country soils, while being surprisingly water stable in their moist state, disperse much more readily once they have been dried.

Jungle soils are more aggregated than the corresponding tea soils, and with the latter the second six inch layer is often more aggregated than the top layer. I do not think this is connected with the clay content, nor with the nature of the clay mineral, and organic matter can not account for the higher aggregation in the subsoil. To some extent ferric hydroxide will, I am sure, be found to be associated with this phenomenon, as also with the aggregation in the mid-country soils, but my progress in these analyses has been so little that I prefer to leave this aspect with the comment that we probably owe a lot to the iron bacteria for keeping some of the soils in their place.

We also are fortunate in that tea requires an acid soil, which automatically means that the predominantly kaolinitic clays are highly aggregated, and that this extends, as far as I can judge, to the full depth of the profile. High aggregation, and therefore rapid penetration of rain, is necessary in the lower layers as well as in the top soil.

I want to revert to my comment on the poorer aggregation often found in the top soil, because this will lead me back to considerations of practical management, and thence to my conclusions.

I attribute much of the friability of the top soil to purely human factors. Tea necessitates repeated and frequent walking in the rows, and in the past the plantations suffered from clean weeding. The implement commonly used for this, a right angled metal strip on a short handle, is the most insidious thing to be found in Ceylon. It almost seems as though it was designed deliberately to reduce the surface soil to dust, and above all to pull it down hill. We must be grateful to the dense mat of the surface feeding tea roots, and possibly to the iron bacteria as well, for re-aggregating the powdered soil and lessening the risk of clogging percolation channels.

The other implement used in cultivation, the long tined fork, also moves soil down hill, but as a block and not as a dust. Here the opening of large percolation channels offsets the disadvantages of assisting the unavoidable tendency of soil to move down steep slopes. Tea requires well drained soil, and in Ceylon this invariably means a steep slope, so that cultivation operations must always have their dangers. How, then, has the Tea Research Institute decided to compromise on this, and what recommendations do we put forward to continue the present trend of increasing vigour of plantation tea?

Let me state them very briefly. To protect the soil from drying out, the tea bush itself should be encouraged to cover it as rapidly as possible. Thus, pruning should be light and no more frequent than is necessary, and plucking and manuring should be designed to give a healthy bush, and not the maximum crop over a short period. On this principle, of the best cover crop for tea being the tea bush, we can see how the other points I raised can be dealt with.

Tea leaves form a stable surface mulch which minimises the trampling damage to the soil. Weeds no longer become a problem under vigorous, dense, tea and the weed scraper with all its harmful effects can, mercifully, be forgotten to a large extent. With a reduction in the clogging of the percolation channels there is less necessity to use a fork, and we may perhaps look forward to the day when some areas need no forking at all.

In mid-country areas this may never be achieved, but here the inclusion of a wad of organic matter behind the fork is suggested to maintain good percolation.

I have purposely said nothing about contour planting, nor about the necessity for protecting drain and bank edges with stones or with the cheaper cover crops. This latter point is a matter for common sense, although it is often ignored.

I have been more concerned to examine the evidence for or against soil conservation under the old up and down tea planting, and to suggest that this tea, which will be with us for many years to come, can, by the adoption of simple agricultural principles, continue to increase its contribution to Ceylon's prosperity with no attendant risk of disgorging Ceylon's greatest asset into the sea.

MISCELLANEOUS NOTES

GUATEMALA GRASS IN RELATION TO *PORIA* AND MEADOW EELWORM

B. N. Webster and G. B. Portsmouth

There has recently been considerable agitation, in Agency House, rather than planting, circles over the possibility of Guatemala grass acting as host to *Poria* root disease, and to meadow eelworm, *Pratylenchus coffeae*, formerly known as *A. pratensis*. A statement of the known facts and present opinions, regarding the above, would appear to be desirable in order to stem the rumours at present circulating and to restore confidence in this very useful green manure material.

Poria and Guatemala Grass.—Guatemala grass has now been grown extensively for some 10 or more years, on many estates, and one of its popular uses has been the planting up of *Poria* patches, following clearing, in order to provide a soil cover until such time as planting up is undertaken. It is difficult to understand why it should have achieved such popularity for this purpose, unless purely on its reputation for providing bulk, as the Institute's recommendation has always been to plant up with a good *Poria*-indicator plant such as *Tephrosia vogelii*, or, if the work has been exceedingly well done, to replant immediately. It is possible that our recommendation to use Guatemala grass as a fallow crop prior to replanting, in order to give the root diseases a chance to die out, may have had some influence on this. Be that as it may the practice is established and no one can quarrel with it, as any opportunity taken to rehabilitate soils, even such relatively small areas as *Poria* patches, is to be commended. During the last 6 or more years only three instances of suspected *Poria* on grass roots have been recorded. Two were definitely positive and one was doubtful. In none of these cases could it be said with certainty that the *Poria* fungus had parasitised living roots, and in none was there any symptom of attack on the aerial portions of the plant. Thus it is not possible to say with any certainty that Guatemala grass is susceptible to *Poria* attack; we can merely state that, in three cases out of the many hundreds of *Poria* patches which have been planted up in Guatemala grass, individual roots have been found carrying *Poria* mycelium. Infection experiments have been initiated to attempt artificial infection of grass roots with portions of infected tea roots, but it is as yet too early to expect any results.

We would conclude with the following advice: where it is deemed desirable to utilise Guatemala grass as a soil cover on *Poria* patches the perimeter of the patch should be planted up with a good indicator plant such as *T. vogelii*, to indicate whether in fact the infection has been contained within the bounds of the patch. On clearing, prior to replanting in tea, the tops should be cut off just above ground level and used for thatching *in situ*. The grass "crowns" remaining should then be removed from as deep as possible with a mammoty and destroyed by burning, or used only for planting up fresh *Poria* patches. On no account should they be used for planting in "clean" areas of soil.

Guatemala Grass and "Meadow" Eelworm.—The position regarding Guatemala grass as a host of the Meadow eelworm, *Pratylenchus coffeae*, is just as indefinite as that regarding *Poria*. Again, over a number of years, this cover has been recommended for eelworm infested areas by virtue of the large bulk of green

organic matter that it is able to provide, and in the hope that during the replanting operation two or more years under its cover would considerably reduce parasitic eelworm populations.

This would be most satisfactory provided that the grass can be proved to be completely resistant to meadow eelworm. So far however no conclusive results have been obtained. Low levels of infestation have been found in fields previously carrying infested tea, after 2 and 3 years under grass, but not after 5 years and 7 years.

It is possible that the residual populations in 2 and 3 year fallows result either from infested field weeds, or from residual living tea roots following the uprooting. This is confirmed to some extent by pot experiments in which heavy applications of meadow eelworms to Guatemala grass growing in sterile soil have died out completely after as short a time as six months.

We feel that on no account should the controlled cultivation of Guatemala grass be discontinued, as it is such a useful cover and provider of bulk organic matter for infested areas, provided it is adequately manured.

The rehabilitation of meadow eelworm infested areas will be dealt with in a separate publication in the *Tea Quarterly*.

STORAGE OF TEA SEED

G. B. Noyes

(Noragalla Estate, Nivitigala)

The *Tea Quarterly* of September 1956 contained an article "Storage of Tea Seed" by Mr. Hume. Last year I tried his recommendations and found I got a 68 per cent germination after 6 months' storage in wooden boxes at 40°F. Although my results are not spectacular, I am satisfied with them as I was able to skim off my surplus seed during a rush period and have this seed when I badly needed it.

It was found that germination was very rapid and even. In 4 weeks all seed that was going to germinate had done so and the roots were much bigger than when fresh seed is germinated. Roots were about 5" long at this time.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON, HELD AT THE OFFICES OF THE PLANTERS' ASSOCIATION OF CEYLON, COLOMBO, ON FRIDAY, 2ND NOVEMBER, 1956, AT 9-45 A. M.

Present.—Mr. F. Amarasuriya (Chairman), Senators T. Amarasuriya, O.B.E. (Chairman, Planters' Association of Ceylon), and E. W. Kannangara, C.B.E. (Chairman, Low-Country Products Association), Mr. R. M. Macintyre Chairman, Agency Section, Planters' Association of Ceylon), Dr. W. R. C. Paul (Acting Director of Agriculture), Messrs. H. S. Amerasinghe, C.C.S. (representing the Hon'ble Minister of Finance), B. Mahadeva, C.C.S. (Acting Tea Controller), R. C. Scott, C.B.E., G. K. Newton, J. L. D. Pieris, A. Divitotawela, W. H. W. Coultas, W. H. Gourlay, B. Amarasuriya, M. B. Butler-Cole and G. B. Portsmouth (Director and Secretary).

Also.—Messrs. G. A. D. Kehl and J. V. Harbord (T.R.I.).

A letter regretting his inability to attend was received from Mr. N. B. Parker.

1. Notice convening the meeting was read.

2. **Minutes of the Board Meeting held on 7th September, 1956**

The minutes were confirmed. Proposed Mr. Scott. Seconded Mr. Mahadeva.

3. **Membership of the Board and Committees**

(i) It was reported that Mr. A. D. McLeod had returned from leave, and would be reassuming his seats on the Board, the Standing Committee and as a Trustee of the Junior Staff Provident Fund as from 3rd November, 1956, vice Mr. W. H. Gourlay, who had been acting for him.

(ii) Mr. A. D. McLeod was nominated to fill Mr. W. H. Gourlay's seat on the Finance Committee as from 3rd November, 1956.

Proposed Mr. Macintyre. Seconded Mr. Mahadeva.

4. **Letter to the Chairman from the Permanent Secretary, Ministry of Agriculture & Food**

"A letter from the Permanent Secretary, Ministry of Agriculture and Food, to the Legal Draughtsman, outlining a proposed amendment of the Tea, Rubber and Coconut Research Ordinances, a copy of which had been sent to the Chairmen of the Boards of the Tea, Rubber and Coconut Research Institutes for their information, was then considered."

It was generally agreed that a formal protest should be made to the Minister in connection with this decision by the Cabinet.

It was decided that an approach should be made to the Rubber and Coconut Research Institutes to ascertain their willingness to send a joint deputation to the Minister, composed of the Chairman and one Board member of each Institute.

It was also agreed that Mr. G. K. Newton should join the Chairman as the representatives of the Tea Research Institute on this deputation.

Proposed Mr. Coultas. Seconded Senator Kannangara.

Mr. Kehl left the meeting at this stage.

5. **Report of the Committee Appointed to Enquire into the Salaries and Conditions of Service of the Staff of the Tea Research Institute of Ceylon**

The Board then gave detailed consideration to the report of this Committee and the Director's notes thereon. The following conclusions were reached and decisions made:—

(I) That the allegations of racial discrimination between the Ceylonese and European members of the staff of the Institute were completely unfounded.

(II) That the existing system of classification and grading of posts contained numerous discrepancies and anomalies, and should be changed as follows:—

The staff to be divided into four categories.

(1) Senior Staff, comprising the Heads of the Technical and Scientific Divisions, the Technical Assistant to the Director, the Secretary to the Institute, who would also become Secretary to the Board, and be designated Administrative Secretary, and the Officer-in-charge of the Small Holdings Advisory Service.

(2) Intermediate Staff, which would contain Research Assistants, the Personal Assistant to the Director, and one Officer in the Small Holdings Advisory Service, who would be designated Assistant to the Officer-in-charge, Small Holdings Advisory Service.

(3) Junior Staff, in two grades, comprising in Grade I Senior Technical Assistants, Chief Accounts Clerk (formerly designated Accountant), Office Assistant, (formerly known as Assistant Secretary), Clerk of Works (formerly Works Clerk), and District Field Officers, (formerly Small Holdings Officers). Grade II to contain Technical Assistants, Clerical and Typing staff, Stenographers, Chief Electrician, Chief Mechanics, Field Assistants, Tea Instructors and the Photographer and Cinema Operator of the Small Holdings Advisory Service.

(4) Minor Staff, comprising Laboratory Attendants, Mechanics, Telephone Operators, Peons, Car Drivers, Watchers, Guest House Keeper, Guest House Cook and Labourers (including Garden coolies).

In June, 1956, the Board had agreed to start a form of cadet training scheme, and had laid down

(*a*) that a potential cadet must be an Honours graduate;

(*b*) that an essential part of the scheme must be a post-graduate course at an overseas university;

(*c*) that the cadet should first serve a period of probation at the Institute to determine his fitness for further training overseas.

It was now agreed in addition that the Institute should obtain a bond from such cadets, enforcing them to take up employment at the Institute after the completion of their training. Mr. Amerasinghe undertook to send the Director a copy of the form of bond used by Government in such cases.

The Board agreed that these cadets should be appointed to the Intermediate Staff as Research Assistants. By the nature of their qualifications and training, they would be eligible in due course, if they were considered suitable, for promotion to the Senior Staff.

It was also agreed that officers, who, though not academically qualified and not therefore suitable for promotion to the Senior Staff, had proved themselves worthy of promotion by long and meritorious service in the Junior Staff, might be promoted to the Intermediate Staff. Such officers would, however, not be eligible for further promotion from this grade.

(III) That the existing salary scales for Ceylonese staff were in general too high in relation to those paid by Government and other bodies to officers carrying out comparable duties. The Board accepted the new scales recommended by the Committee. However in the case of the Junior Staff, it was agreed that the designation "Promotion Grade" should be used instead of "Selection Grade."

(IV) That a defect in the existing organisation had been the failure to lay down definite minimum educational qualifications for posts (particularly on the Senior Staff). The Board accepted the Committee's recommendations, except in the case of Minor Staff, where they thought it was unnecessary to demand a Junior School Certificate as a qualification.

With regard to the existing officers holding posts without the requisite academic qualifications, it was agreed that, since most of them had served the Institute for long periods, they should be retained until they reached the age of 55, but not beyond this age unless it was impossible to recruit suitably qualified officers in their place.

(V) That the Director in the past had been saddled with too much unnecessary work of a purely administrative nature. It was agreed that the post of Secretary be redesignated Administrative Secretary, and that this officer should take over the duties of Secretary to the Board in addition to being Secretary to the Institute. This would be a Senior Staff post on the same salary scale as for the Research and Technical Officers. On the retirement of the present Secretary, a suitably qualified professional man would be appointed to this post.

(VI) That new officers recruited from overseas should be excluded from the classified staff of the Institute. Such officers should be specifically appointed as necessary on contracts and the emoluments fixed by negotiation in individual cases.

(VII) That the existing practice of paying Senior Staff dearness allowance at Ceylon Planters' Society rates should not be continued in the case of Ceylonese officers appointed to senior posts after January 1st, 1957, (whether by recruitment from outside or by promotion from lower grades). All Ceylonese staff of the Institute would be paid dearness allowance at Government rates, except that officers receiving over Rs. 500 per mensem would be entitled to draw the same allowance as officers receiving Rs. 500 per mensem. Senior Ceylonese officers now in the service of the Institute would continue to enjoy the Ceylon Planters' Society rate of allowance as personal to them. With regard to staff recruited from overseas, no dearness allowance would be paid, and this would be taken into consideration in fixing the salary

of the recruit. Present overseas staff would retain their existing allowance as personal to them.

(VIII) That where official quarters are available, rent free quarters should continue to be provided.

(IX) That the present scale of housing, particularly for some of the Junior Staff, was slightly extravagant. It was agreed that, for future construction, houses should be limited in size as follows:—

	Maximum area
Senior Staff houses	3,300 sq. ft.
Intermediate Staff houses ...	2,200 sq. ft.
Junior Staff Grade I houses ...	1,400 sq. ft.
Junior Staff Grade II houses ...	1,200 sq. ft.
Minor Staff houses	600 sq. ft.

(X) That basic hard furniture should be provided for all employees in official free quarters. Future recruits would not be provided with any items of soft furnishings, but officers at present provided with such items would be allowed to continue to enjoy the privilege.

(XI) That officers not provided with official quarters should be paid house allowances in lieu at the following rates:—

Officer-in-charge, Small Holdings Advisory Service	10% of basic salary.
Mr. Fonseka	Rs. 100 per mensem
District Field Officers	Rs. 75 „ „
Tea Instructors (married) ...	Rs. 30 „ „
„ „ (single)	Rs. 15 „ „

The rates are the same as those now in force, except in the case of Mr. Fonseka, whose allowance has been increased by Rs. 25 per mensem.

(XII) That new recruits should not be paid any servants allowances, but that the Institute should directly employ any labourers necessary for tending these officers' gardens. Officers at present enjoying these allowances should retain them as personal to them. In the case of overseas officers recruited in future, the removal of the allowance should be taken into account in fixing the officer's salary.

(XIII) That the present electricity allowances and provison of free piped water be continued, and that electric lights be provided for all quarters as early as possible.

(XIV) That when an officer is allowed to use his private car for official purposes, the existing mileage rates be amended to the following rates:—

Class		*Cents per mile*
I	Private car weighing over 21 cwt.	55
II	Private car weighing over 17 cwt. but not over 21 cwt.	45
III	Private car weighing over 14 cwt. but not over 17 cwt.	40
IV	Private car weighing over 12 cwt. but not over 14 cwt.	30
V	Private car weighing 12 cwt. and under ...	25
VI	Motor cycles	20

Only Senior Staff to be entitled to Class I rates; Senior and Intermediate Staff to Class II and III rates; all staff, except Minor Staff, to Class IV, V and VI rates.

(XV) That the Field and/or Car allowance paid to officers of the Small Holdings Advisory Service and certain out-station officers be abolished, and these officers compensated.

(XVI) That the following subsistence and lodging allowances should be put into effect as from 1-1-57:—

	Subsistence per day	*Lodging per day*
1. Senior Staff.		
(*a*) For accommodation at a club or hotel in Colombo, Kandy, Galle, Nuwara Eliya, Bandarawela or Badulla	Rs. 17.50	Rs. 10.00
(*b*) For accommodation at resthouse ...	Rs. 10.00	Rs. 7.50
(*c*) For accommodation on estates or with friends	Combined rate of Rs. 10.00	
2. Intermediate Staff.		
(*a*) For accommodation at a club or hotel in Colombo, Kandy, Galle, Nuwara Eliya, Bandarawela or Badulla	Rs. 10.00	Rs. 7.00
(*b*) For accommodation at resthouse ...	Rs. 10.00	Rs. 4.00
(*c*) For accommodation on estates or with friends	Combined rate of Rs. 8.00	
3. Junior Staff.		
Grade I	Rs. 9.00	Rs. 3.00
Grade II	Rs. 8.00	Rs. 2.50
4. Minor Staff.		
(*a*) Salaries over Rs. 120 per mensem ...	Combined rate of Rs. 6.50	
(*b*) Salaries over Rs. 100 but not exceeding Rs. 120 per mensem	Combined rate of Rs. 5.00	
(*c*) Salaries not exceeding Rs. 100 per mensem	Combined rate of Rs. 3.00	

Car drivers batta Rs. 5 per day for trips to Colombo, Kandy, Galle and Badulla and Rs. 3 per day for other trips.

(XVII) That sleeping berths should be granted with the three sets of railway warrants allowed annually to all Ceylonese officers. Senior, Intermediate and Grade I Junior Staff to be entitled to 1st class warrants. Grade II Junior Staff to 2nd class warrants and Minor Staff to 3rd class warrants.

(XVIII) That the leave terms for overseas recruited officers should be those set out in the draft contract approved by the Board on 2nd September, 1955. As regards passages, medium-priced first-class passages at rates applicable in (say) the P. & O. or Orient Line will be provided. An officer electing to travel at a cheaper rate will not be entitled to the difference in cash.

Ceylonese Senior Staff officers will be entitled to the same leave terms as Government staff officers of the old entrant group. Mr. Amerasinghe undertook to send

the terms to the Director. Any senior officer, who did not elect to take his accumulated leave, would not be entitled to cash in lieu.

Ceylonese Intermediate and Junior Staff officers will be entitled to four weeks leave per annum, and Minor Staff to two weeks per annum. This leave would be exclusive of sick leave on medical certificate and could be accumulated for a maximum of two years.

(XIX) That the Board should continue to pay half the medical expenses of the Senior Staff, and that the Intermediate Staff should be treated similarly. In the case of the Junior Staff, which had a contributory scheme, it was agreed that, where an officer's medical bills exceeded the amount standing to his credit in the Medical Fund, the Institute should pay half the excess. In the case of the Minor Staff, the present practice should continue.

(XX) That the present Provident Fund be continued unchanged. It was agreed that in the case of officers recruited before 1st October, 1936, an ex-gratia retiring gratuity should be given in addition to the normal Provident Fund. The amount of such gratuity would be determined by the Board in each individual case. The Director was asked to enquire whether the Board had the powers under the Ordinance to put this decision into effect. If necessary, the Ordinance should be amended.

The Committee recorded its appreciation of the services of Mr. Seneviratne and Mrs. Dharmadasa of the Tea Control Department who had acted as Secretary and Typist respectively to the Committee. Both of them had been given an honorarium. The Board endorsed the Committee's appreciation.

Mr. Macintyre, on behalf of the Committee, paid tribute to Mr. Mahadeva's work, and Mr. Scott added the names of the Chairman and Mr. Macintyre to this tribute. On the proposal of Mr. Scott the Board unanimously adopted the report, subject to any amendments made by the decisions recorded in these minutes.

6. **Any Other Business**

(i) The Board approved the sealing of the following documents:—

(1) Lease of land at Gonakelle, together with rights of way and right to water supply from existing pipe lines, as defined by the Figure of Survey dated 7-9-55 made by Mr. V. J. C. Jonklaas.

(2) Lease of land at Neuchatel, together with right of way, as defined in Survey Plan No. 50 dated 27-4-56 made by Mr. A. A. Keegel.

(3) Transfer of land with Lindoola Estate, as defined in Survey Plan No. 269A, dated 28-5-56 made by Mr. H. D. Smith.

(4) Transfers of land with Mattakelle Estate, as defined in Survey Plan No. 270A dated 25-5-56 and Survey Plan No. 604 dated 27-3-56, both made by Mr. H. D. Smith.

Proposed Mr. Divitotawela. Seconded Mr. Macintyre.

(ii) Senator Kannangara then spoke to the following resolution, which had been circulated to the Board together with correspondence between Senator Kannangara and the Director,

"In view of the resolution passed by the Low-Country Sub-Committee of the Board of the Tea Research Institute on 18th October, 1954, which was unanimously adopted by the Board at its subsequent meeting, that the words '(i) to submit a report within one year on the organisation of a low-country sub-station' in paragraph 3 of item 9 of the minutes of the meeting of the Board held on 7th September, 1956, *be deleted*, and the following words substituted therein '(1) to enquire and report within six months on a suitable and central low-country *site* preferably in tea and rubber with or without tea factory facilities to establish a low-country sub-station'."

After some discussion members agreed that the minutes of the Board meeting of 7th September, 1956, satisfactorily set out the Board's policy decisions with regard to the low-country, and Senator Kannangara's resolution was not adopted.

Some exception was taken by the Board to the tone of the Director's letter of 29th October, 1956, to Senator Kannangara, and Mr. Portsmouth apologised and unreservedly withdrew the offending passages. This was accepted by all members of the Board.

The meeting ended at 1-10 p.m., with a vote of thanks to the Chair.

Sgd. G. B. PORTSMOUTH,
Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakelle.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE OFFICES OF THE PLANTERS' ASSOCIATION OF CEYLON COLOMBO, ON FRIDAY, 7TH DECEMBER, 1956, AT 9-30 A. M.

Present.—Mr. F. Amarasuriya (Chairman), Senator T. Amarasuriya, O.B.E. (Chairman, Planters' Association of Ceylon), Mr. R. M. Macintyre (Chairman, Agency Section, Planters' Association of Ceylon), Dr. W. R. C. Paul (Acting Director of Agriculture), Messrs. B. Mahadeva, C.C.S. (Tea Controller), R. C. Scott, C.B.E., G. K. Newton, J. L. D. Peiris, V. G. W. Ratnayaka, M.B.E., N. B. Parker, A. D. McLeod, A. G. Divitotawela, W. H. W. Coultas, G. J. Harris and J. A. H. Tolhurst (Acting Director and Secretary).

Also.—Messrs. G. A. D. Kehl, E. S. Rose and J. V. Harbord (T.R.I.).

1. Notice convening the meeting was read.

The Chairman welcomed Mr. McLeod and Mr. Harris back from their leave. The Board recorded their appreciation of Mr. Butler-Cole's services on the Board and Building Committee during Mr. Harris's absence.

2. Minutes of the Board Meeting held on 2nd November, 1956

The minutes of the meeting held on 2nd November, 1956, were confirmed, after a tabled amendment to item 6(ii) by Senator Kannangara had been considered and the item amended to read as follows:—

> "After some discussion members agreed that the minutes of the Board meeting of 7th September, 1956, embodied what was contemplated by Senator Kannangara in his proposed amendment and satisfactorily set out the Board's policy decisions with regard to the low-country, and therefore, on Senator Kannangara's concurrence, the resolution was not put to the meeting by the Chairman."

3. Matters Arising out of the Minutes

(i) Letter to Chairman from Ministry of Agriculture and Food.—The Chairman was unable to report any progress. The Board agreed that the Chairman should take the initiative and pursue the matter as vigorously as possible in order to obtain a hearing with the Minister of Agriculture.

(ii) Report, etc. Para. (X). Furniture.—There was some doubt as to how the second sentence of this paragraph was to be interpreted. The Board agreed that the following words should be added to the end of the sentence:—

> "as long as they are in the Institute's service."

The Board also agreed that a refrigerator should be considered part of the basic hard furniture of Senior Staff houses. It was decided that at St. Coombs the refrigerator should be of 5½ cu. feet capacity and in the low-country of 7 cu. feet capacity.

(iii) Report, etc. Para (XVII). Railway Warrants.—It was agreed that the three railway warrants allowed annually to all Ceylonese officers should all be open for travel to any station in Ceylon.

(iv) Report, etc. Para (XVIII). Leave terms for Ceylonese Staff.—On Mr. Mahadeva's suggestion, the Board agreed to amend the first sentence of the second paragraph of this section to read as follows:—

> "Ceylonese Senior Staff officers will be entitled to the same leave terms as Government staff officers recruited between 1934 and 1945."

The Board also agreed to amend the last sentence of the third paragraph of this section to read as follows:—

> "This leave would be exclusive of sick leave on medical certificates, and Intermediate Staff would be allowed to accumulate leave for a maximum of two years",

It was also agreed that for absences of three days or less a medical certificate would not be necessary.

4. Minutes of the Finance Committee Meeting held on 6th September, 1956

The minutes were formally approved.

Proposed Senator Amarasuriya. Seconded Mr. Parker.

5. **Minutes of the Small Holdings Committee**

Meeting held on 6th September, 1956

The minutes were formally approved.

Proposed Mr. Newton. Seconded Senator Amarasuriya.

6. **Minutes of the Standing Committee**

Meeting held on 2nd November, 1956

Building Programme.—Mr. Peiris explained that the unsettled political conditions had compelled Messrs. Hemachandra & Co. to ask for the insertion of a clause in the contract to cover them against any rise in the cost of materials. They had been asked to submit a list of materials likely to be affected to the Institute's consulting architects. If the request was considered reasonable, the architects had suggested meeting the case by building three instead of four senior staff houses, and leaving the contract figure already approved by the Board at the same figure. This would overcome the danger of any delay which would be incurred if a fresh figure had to be approved.

A letter from the Architects, recommending that the extensions to the Guest House should be carried out by the Institute's baas, was read. The Finance Committee had recommended the acceptance of the architect's proposals. The Board agreed.

The minutes of the Standing Committee were approved.

7. **Minutes of the Experimental and Estate Committee**

Meeting held on 10th November, 1956

The views of this Committee and those of the Finance Committee with regard to the combining of the Estate and Institute accounting in one office were considered at some length.

The Board finally decided to accept the recommendation of the Experimental and Estate Committee to keep the accounting of the Estate and Institute in separate offices.

Mr. Macintyre raised the question of phloem necrosis and Mr. Tolhurst repeated what he had said at the Finance Committee meeting that progress was being made within the limits imposed by lack of trained assistant staff, and subject to demands made by other serious diseases. The minutes were approved.

Proposed Senator Amarasuriya. Seconded. Mr. Peiris.

8. **Finance**

(i) Accounts of the Institute as at 31st October, 1956.—The comments of the Finance Committee were read, and the accounts adopted subject to their recommendations.

(ii) Investments.—The Finance Committee's recommendations were approved. It was also decided that applications for suitable investments should be given at once to Brokers for holding.

(iii) Estimates for 1957.— (a) St. Coombs Estate.— The comments and recommendations of the Finance Committee were read.

With regard to the appointment of an Acting Superintendent, Mr. Newton explained the procedure which had been previously adopted to obtain the services of a Superintendent through the Agency Houses. The Acting Director was asked to write to the Secretary of the Planters' Association immediately, requesting him to inform Agency members of the vacancy.

Mr. Coultas commented on the high estimated cost of production, but after hearing Mr. Newton's comments it was agreed to make no alteration.

Subject to the Finance Committee's recommendations the estimates were adopted.

Proposed Mr. Parker. Seconded Mr. Ratnayaka.

(b) SMALL HOLDINGS ADVISORY SERVICE ESTIMATES.—These were adopted, subject to the amendments recommended by the Finance Committee.

Proposed Mr. Ratnayaka. Seconded Senator Amarasuriya.

(c) T.R.I. ESTIMATES.—The estimates were approved, subject to the amendments recommended by the Finance Committee.

Proposed Mr. Ratnayaka. Seconded Mr. McLeod.

9. **Staff**

(i) Letter from Mr. J. V. Harbord.—Mr. Harbord's resignation was accepted, and it was agreed that his employment should terminate on 15th January, 1957, and that his 5 months leave start from this date. Mr. Scott paid tribute to Mr. Harbord's services during his period in the Board's service. Thanking Mr. Scott, Mr. Harbord recorded his appreciation of the help and encouragement which he had always received from Mr. Portsmouth during his term as Director.

(ii) A request from four officers asking that loans for cars should be repayable over a five year period instead of three was rejected.

10. **Any Other Business**

(i) It was reported that approval had been given by the Board for the publication of the Annual Report of the Board for 1955, vide Circular No. A33/56 of 17-9-56.

(ii) The Acting Director said that steps would be taken as early as possible to obtain Research Assistants.

The meeting ended at 1 p.m., with a vote of thanks to the Chair.

Sgd. J. A. H. TOLHURST,
Acting Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakelle.

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD AT THE OFFICES OF THE PLANTERS' ASSOCIATION OF CEYLON COLOMBO, ON FRIDAY, 22ND MARCH, 1957, AT 9-30 A.M.

Present.—Mr. F. Amarasuriya (Chairman), Mr. R. M. Macintyre (Chairman, Agency Section, Planters' Association of Ceylon), Dr. M. F. Chandraratna, M.B.E. (Director of Agriculture), Senator T. Amarasuriya, O.B.E. (Chairman, Planters' Association of Ceylon), Senator E. W. Kannangara, C.B.E. (Chairman, Low-Country Products Association), Messrs. B. Mahadeva, C.C.S. (Tea Controller), R. H. Wickramasinghe, M.B.E. (representing the Minister of Finance), R. C. Scott, C.B.E., W. H. W. Coultas, G. J. Harris, A. G. Divitotawela, V. G. W. Ratnayaka, M.B.E., A. D. McLeod, N. B. Parker, J. L. D. Peiris, G. K. Newton, G. B. Portsmouth (Director, T.R.I.) and G. A. D. Kehl (Secretary).

1. Notice convening the meeting was read.

A message regretting inability to attend was received from Mr. B. Amarasuriya.

The Chairman welcomed Dr. Chandraratna who was attending a meeting of the Board for the first time, and also Mr. Wickramasinghe who had returned from leave.

2. **Minutes of the Board Meeting held on 7th December, 1956**

The minutes of the meeting of the Board held on 7th December, 1956, were confirmed.

3. **Matters Arising out of the Minutes**

(i) Letter to Chairman from Ministry of Agriculture and Food.—It was reported that a Bill to amend the Tea Research, Rubber Research and Coconut Research Ordinances had passed all its stages in the House of Representatives on the 7th March and in the Senate on the 13th of March.

Following representations the Prime Minister had agreed to delete the words "or special" which had been included in the orginal draft so that the Bill as passed read as follows:—

> "In the discharge of its functions and the exercise of its powers, the Board shall be subject to, and act in accordance with, such general directions as the Minister may issue from time to time."

(ii) Investments.—It was reported that the sum of Rs. 400,000/- had been invested in Ceylon Government 3% Loan 1970/73 stock on the 15th February, 1957.

(iii) V. P. Expansion.—It was reported that the Superintendent, Neuchatel Estate, had informed Dr. Joachim that the bungalow rented by the Tea Research Institute was likely to be required by the estate in four or five years' time.

The Director stated that he proposed to improve the water supply, which at at present, was quite inadequate. Most of the expenditure would be recoverable in the event of the bungalow being vacated.

4. **Membership of the Board and Committees**

(i) It was reported that Dr. M. F. Chandraratna had become an ex-officio member of the Board on his appointment as Director of Agriculture with effect from 1-1-57.

(ii) It was reported that Mr. R. H. Wickramasinghe had returned from leave and was resuming duties as the representative of the Hon'ble Minister of Finance on the Board as an ex-officio member thereof.

5. **Minutes of the Small Holdings Committee Meeting held on 5th December, 1956**

The minutes were approved.

6. **Minutes of the Finance Committee Meeting held on 6th December, 1956**

The minutes were approved.

7. **Minutes of the Estate and Experimental Committee Meeting held on 2nd March, 1957**

Mr. Macintyre commended the formation of a new Eelworm Sub-Committee and suggested that a Phloem necrosis Sub-Committee should also be formed on similar lines.

The Board generally endorsed the principle of the formation of Sub-Committees to co-ordinate experimental work on specific research problems.

Mr. Macintyre stated that he was also pleased to note that the Estate and Experimental Committee had decided to retain the direct fired heater in St. Coombs factory.

In this connection the Director re-assured the Board that in arriving at this decision the Committee had particularly stressed that the direct fired heater would be used for experimental purposes only.

Mr. Coultas enquired whether the St. Coombs mark had any influence on the prices secured for St. Coombs teas.

In reply Mr. Newton explained that it had taken a great deal of effort by all concerned to build up the reputation now enjoyed by the St. Coombs teas in the Colombo market. But once such a reputation had been secured, then the mark undoubtedly would attract keen buyers. It was for this reason that he was particularly concerned that the direct fired heater should not be used for normal manufacture.

The minutes were approved.

8. **Minutes of the Standing Committee Meeting held on 8th March, 1957**

(i) Proposed transfer of the Small Holdings Advisory Service to the Department of Agriculture.—The Chairman reported that in accordance with the decisions of the Standing Committee he had attended a meeting with the Director of Agriculture at Peradeniya yesterday morning at which the Tea Controller and the Director were also present.

(ii) Building programme.—The Board approved the restoration of this item to the 1957 estimates. It was noted that the amended cost for building 3 double blocks of minor staff quarters would be Rs. 58,000/-.

(iii) Leave terms for Ceylonese Senior Staff Officers.—The Director drew the Board's attention to the fact that the recommendation made by the Standing Committee to accept the same leave terms as for those officers appointed to the Public Service prior to 24th April, 1933, appeared to conflict with the decision made by the Board at the meeting held on 7th December, 1956, which read "Ceylonese Senior Staff officers will be entitled to the same leave terms as Government staff officers recruited between 1934 and 1945."

The Standing Committee's recommendation was however in conformity with a number of previous decisions of the Board. The Director further pointed out that the confusion could be eliminated if the Board agreed to make the leave terms approved at the last Board meeting applicable only to officers entering the service of the Board after 1st January, 1957.

Officers who had entered the Board's service prior to that date should however continue to enjoy the terms previously granted to them which would now be defined as those applicable to officers appointed to the Public Service prior to 24th April, 1933.

This was approved.

The Board however wished it clearly to be understood that the right to apply for overseas leave was restricted to Senior Staff officers.

(iv) Position of the Director on the Board.—The position of the Director in relation to the Board, following Mr. Kehl's appointment as Secretary to the Board, was considered.

It was recommended that the Director should be an ex-officio member of the Board.

Mr. Mahadeva offered to take up the question of any necessary amendment to the Ordinance with the Ministry.

(v) Post of Pathologist.—The Director reported that only two applications had been received by the closing date, *i.e.* the 13th of March, 1957. One of these applicants had no post-graduate degree whilst the other, who was presently employed in the Department of Agriculture, could not be released.

The Director was accordingly instructed to advertise the post overseas as widely as possible.

(vi) Post of Research Assistants.—The Director asked the Board to note the position which he had previously fully explained to the Standing Committee. He would like to know whether the Board wished the Appointments Committee to be called to interview the two possible candidates.

The Board agreed that this should be done. The Director of Agriculture was also nominated as an additional member of the Appointments Committee.

It was also suggested that close liaison should be maintained with the University authorities regarding the availability of possible candidates.

The Director stated that he had already been in contact with the University authorities.

The minutes were approved.

9. **Staff**

(i) Mr. G. B. Portsmouth, Director.—It was reported that Mr. Portsmouth had returned from leave on 15th February, 1957.

(ii) Mr. J. V. Harbord, Technical Assistant to the Director.—It was reported that Mr. Harbord had left Ceylon on 15th January, 1957.

10. **St. Coombs Estate**

(i) Post of Superintendent.—Mr. Newton reported that when applications had closed on the 20th of February, a total of 21 applications had been received. Three short-listed candidates had been interviewed by himself, the Chairman and the Director on the 8th of March when Mr. T. B. Pethiyagoda was unanimously selected for appointment.

The appointment of Mr. Pethiyagoda as Superintendent of St. Coombs was approved.

(ii) The Director reported that Mr. Rose had handed over St. Coombs estate to Mr. C. W. C. Mossop of Waltrim estate on the 15th of March and that arrangements had been made for Mr. Mossop to overlook St. Coombs until such time as Mr. Pethiyagoda was able to take up his appointment which, it was hoped, would be on or before the 1st of May, 1957.

(iii) Staff Bonuses for 1956.—Mr. Newton stated that although the yield for 1956 was only 246, 420 lbs. the profit on the estate working, subject to audit, amounted to Rs. 302,790/- as compared with the profit of Rs. 322,031 for 1955.

This excellent result could largely be attributed to the very high prices obtained for St. Coombs teas, which had averaged Rs. 3.19 for the year as compared with the high grown average of Rs. 2.66.

The recommendations were approved.

The Board recorded their congratulations to all concerned for the excellent results obtained in spite of adverse climatic conditions in the early part of the year.

11. **Any Other Business**

(i) Low-country Sub-Station.—Following a request from Mr. Peiris an interim report from Dr. A. W. R. Joachim was tabled for the information of members.

(ii) Resignation of the Director.—The Chairman reported that a letter of resignation from the Director, Mr. G. B. Portsmouth, dated 11th March, 1957, had been circulated to the Board under Circular No. A.6/57 dated the 19th March, 1957.

Several members expressed regret and asked Mr. Portsmouth whether he was prepared to reconsider his decision. Mr. Portsmouth regretted that it was

impossible for him to alter his decision. The Board thereupon accepted his resignation.

(iii) Consultative Committee on Tea.—It was reported that Mr. Illankoon, O.I.C., Tea Small Holdings Advisory Service, had been invited by the Minister of Commerce and Trade to serve on the Consultative Committee on tea trade which was set up recently.

Mr. Illankoon had accepted the invitation subject to the approval of the Board. This was granted.

(iv) Appointment of Deputy Director.—The Director stated that in view of his impending departure there was much information which he would have to hand over to some responsible officer during the course of the next few months. He therefore felt that the time had come to fill the post of Deputy Director.

After some discussion the appointment of Mr. J. A. H. Tolhurst as Acting Deputy Director was approved with effect from 1st April, 1957.

The meeting terminated at 1 p.m. with a vote of thanks to the Chair.

Sgd. G. A. D. KEHL,
Secretary.

Tea Research Institute of Ceylon,
St. Coombs,
Talawakelle.

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